SCIENCE ABSTRACTS.

Section A.—PHYSICS.

NOVEMBER 1920.

GENERAL PHYSICS.

1350. *Ultra-Micrometer.* **R. Whiddington.** (Engineering, 110. p. 384 with Disc., Sept. 17, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—This instrument is a valve arrangement for measuring extremely minute distances of the order of atomic diameters. The principle is that a very slight change in the distance between the plates of the condenser in circuit with the valve makes a very great change in the frequency of the oscillations, and if the valve is arranged for heterodyne-beat receiving the instrument becomes very delicate. **E. Rutherford, F. E. Smith,** and **P. E. Shaw** emphasised the extreme sensitiveness of valves to any disturbance, the near approach of the hand being sufficient to alter the capacity of the system and hence render the indications unreliable. The **Author** stated that the apparatus was shielded with tin-lined boxes, and that it was necessary to work at night. A. W.

1351. *Testing Parallelism of Glass Plates.* **H. Krüss.** (Zeits. Instrumentenk. 40. pp. 33–37, Feb., 1920.)—Describes an instrument for determining the departures from plane-parallelism of glass plates up to 12 × 12 cm., at various points on their surfaces. The instrument is a modification of that of Plath and Eylert, consisting of two telescopes, each inclined to the horizontal at an angle of about 20°, the image of the cross-wires of one telescope being seen in the other by reflection in the upper surface of the plate. The angle by which the plate has to be tilted in order to restore coincidence of image when the plate has been moved round through 180° is equal to twice the angle of slope of the upper surface of the plate at the part where the light is reflected. J. W. T. W.

1352. *Harmonic Analyser.* **V. Bush.** (Am. I.E.E., J. 39. pp. 903–905, Oct., 1920.)—The simple analyser here described will evaluate the integral $\int f(x) \sin (\omega x + \beta) dx$, where $f(x)$ is any known single-valued function. Hence it is suitable for the determination of the harmonics of an irregular function, such as the current or voltage curve given by an oscillograph. The analyser consists of a set of transparent discs, preferably of celluloid, a planimeter of any convenient form, and a piece of silk fishing line. The edge of each disc is grooved, the diam. at the bottom of the groove being d, less the thickness of the line used. The upper surface carries two depressions, A and B, connected by a straight trough. A is at the centre of the disc, and B at a radius $d/2$. In the centre of the bottom surface of the disc is a dot, and the disc is graduated in degrees, clockwise from the trough, the graduations being preferably on the lower surface. The curve to be analysed is plotted to a convenient scale in rectangular coordinates, and placed in the centre of a long table. A disc of size corresponding to the desired component is placed on the curve. The scale should be so chosen that if a disc of diam. d is to be used, and the nth harmonic required, one complete period of the curve covers a distance πdn. The line is then given a single turn clockwise about the disc, and fastened to the ends of the table after being pulled fairly taut. The horizontal axis of the curve is arranged so as to be parallel with the line. The disc is now placed with its centre at the origin of the curve, and the trough making an angle β with the horizontal axis. If β is zero, a sine component will be obtained; if 90°, a cosine component. The planimeter point is placed in depression B, and the planimeter scale set at zero. By placing a sharp point in the depression A, the centre of the disc is now made to traverse the path out along the horizontal axis, and back along the curve to the origin. To the reading of the planimeter is now added the area under the curve. The result divided by half the length of the base of the curve gives the ordinate of the desired component in terms of the constant of the planimeter. Thus if the planimeter reads in square inches, the final area reading is to be multiplied by two, divided by the base of the curve in inches, and the ordinate will be in inches. This value may then be interpreted in terms of the scale of the curve. If several components are desired, they may be determined most conveniently by separate discs. A table of disc sizes, scales, and order of components is given, and the theory of operation is set out in an appendix. The accuracy of the device appears to be limited by the accuracy of the planimeter, but results can be relied upon to that accuracy, which is sufficient for many purposes. A. W.

1353. *Precision Isotomeograph.* **J. G. Hagen.** (Zeits. Instrumentenk. 40. pp. 65–70, April, 1920.)—Describes in detail, with illustration, the isotomeograph installed at the Vatican Observatory. The bifilar suspension is 685 cm. long, the wires being 3 cm. apart. The total moving weight is 88·6 kg. of which the rolling weights form, together, two-thirds. The value of $w \sin \phi$ found from the instrument agrees with the theoretical value to 0·2 %. J. W. T. W.

1354. *An Auto-ballistic Pendulum.* **A. Guillet.** (Comptes Rendus, 170. pp. 1310–1313, May 31, 1920.)—A rod of invar, length 113·5 cm., carries two brass weights, each about 3200 gm., displaceable at will by a micrometer. Attached to the pendulum at its centre of percussion is a double U-magnet with four poles forming an astatic system. At the top is fixed an Al fitting with axis coincident with the axis of suspension, and a mirror is attached at this axis. Independently held, are four bobbins, currents in which act inductively on the magnet and automatically maintain the pendulum vibration. During the two months in which observations were made the amplitude remained constant. P. E. S.

1355. *Sun-Dial giving Approximate Day of the Year and Legal Time for practical purposes corrected for Equation of Time.* **C. Gautier.**

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(Comptes Rendus, 170. pp. 1301–1303, May 31, 1920.)—The style forms part of the axis of a hollow cylinder, whose internal surface is divided into hours in one direction and dates in the other. A subsidiary plate with a bean-shaped curve marked at ten-day intervals regulates a small rotation of the cylinder, which enables three different times to be read off: true local time, Greenwich mean time, and "Summer time." The instrument is claimed to give the date accurately at the equinox, and the time within 1 minute, also the time of sunrise and sunset and the length of the day. W. W. B.

1356. *Latitude by Observation of Sunrise or Sunset.* **N. Liapin.** (Observatory, 43. pp. 224–226, June, 1920.)—An observer with an ordinary watch can determine the time interval between the rising or setting of the upper and lower limbs of the sun. This interval is clearly sufficient to determine the latitude if accurately measured. A sea horizon is best, to ensure the level being the same at both points observed. Thus no correction for refraction is required. For obvious reasons sunset is preferable to sunrise. The author gives six of his own determinations in the grounds of Odessa Observatory, ranging from 46° 15′ to 46° 57′ with a mean of 46° 39′, the true value being 46° 29′. In high latitudes near the solstices the probable error would be very small. W. W. B.

1357. *Electric Chronography: Sound Ranging.* **Pellion.** (Soc. Franç. Elect., Bull. 10. pp. 203–221, June, 1920.)—A general survey of graphical methods of recording short intervals of time by traces on smoked surfaces and by photographic records. The paper is illustrated by numerous diagrams of which eight are on the subject of sound ranging as recently conducted. Without reproduction of these it is difficult to abstract the work in detail. E. H. B.

1358. *Measurement of Time.* **N. R. Campbell.** (Phil. Mag. 40. pp. 161–162, July, 1920.)—The author claims that the assumptions of a uniform motion in time measurement has no experimental ground, and suggests that it owes its general acceptance to its prediction of true laws. The pendulum and the tuning-fork as time-measuring instruments do not depend on any such assumption. He claims that neither distance nor temperature are fundamental magnitudes. [See Abs. 962 (1920).]

G. W. de T.

1359. *Theory of Strains in Quickly Cooled Glasses.* **J. Salpeter.** (Zeits. f. Physik, 2. 1. pp. 13–17, 1920.)—The magnitude of the strains set up in quickly cooled glasses depends on the temperature distribution within the substance during solidification, and on the difference of the specific volumes in the fluid and solid states. The present paper gives a mathematical treatment of the effect of these two factors on the strains developed in a quickly cooled sphere. A. W.

1360. *Theory of the Elasticity and Fragility of Isotropic Solids.* **M. Brillouin.** (Ann. de Physique, 13. pp. 217–235, May–June, 1920.)—A general historical and critical account of the limits of elasticity and the plasticity resulting from great deformations. F. C. T.

1361. *Some Applications of Hertz's Theory of Impact.* **C. V. Raman.** (Phys. Rev. 15. pp. 277–284, April, 1920.)—*Statement of the Theory.*—One of the premises on which the mathematical theory of the collision of elastic solids given by Hertz is based is that the strains produced in the immediate neighbourhood of the region of contact are determined by the pressure subsisting at any instant between the bodies, and are practically the same as under statical conditions. This premise is valid even when the impinging bodies do not move as rigid bodies, and the impact results in part of the translational kinetic energy being transformed into energy of elastic wave-motion in the substance of the solids. *Hertz's theory of impact* with suitable modifications may accordingly be applied under a very wide variety of conditions. In the present paper, an attempt is made to discuss the problem of the *transverse impact of a solid sphere on an infinitely extended elastic plate of finite thickness* and to calculate the theoretical *coefficient of restitution* which is a function of the elastic constants and the densities of the materials, the diam. of the sphere and the thickness of the plate, and of the velocity of impact. As the result of the impact, annular waves of flexure are set up in the plate, and the sum of the kinetic and potential energies of the wave-motion may be determined in terms of the magnitude and duration of the impulse on certain simplifying assumptions. The calculation results in a *simple formula for the coefficient of restitution*.

Experiments.—A series of *experiments* carried out in the author's laboratory by A. Venkatasubbaraman has furnished a quantitative confirmation of the formula within the limits of its applicability, that is for plates not thinner than about half the diam. of the spheres. For plates much thinner than this, theory and experiment agree in indicating a zero coefficient of restitution. The formula indicates that the coefficient of restitution should increase and approach unity for greatly diminished velocities of impact, and this is also confirmed in experiment. The paper concludes with indications of some *further applications and extensions* of Hertz's theory of impact. AUTHOR.

1362. *New Facts about Surface Friction.* **C. Terzaghi.** (Phys. Rev. 16. pp. 54–61, July, 1920.)—*Friction between smooth surfaces: physical properties of clays.*—In the present paper the author discusses a number of preliminary experiments leading to an investigation of the physical properties of clays. Since plastic deformations of clay-bodies involve the sliding of the smooth clay particles upon each other, in order to determine the character and the laws governing the frictional forces, the author studies the behaviour of smooth glass plates placed in contact under different conditions of loading. As a result of these experiments it is established that the frictional resistance between two surfaces is not due to the shearing strength of a cushion of air or water, but to the existence of microscopic particles that deposit themselves on the rubbing surfaces. Frictional resistance was found to be independent of the thickness of the air cushion.

Properties of very thin layers of water; permeability and water contents of clays.—A drop of water was placed between two glass plates and was allowed to evaporate. When the thickness of the layer of water was reduced to about 100$\mu\mu$, the evaporation stopped completely, suggesting that the molecules of a solid are able to exert forces over distances of the order of 50$\mu\mu$. Such thin layers of water have, besides viscosity, shearing and tensile strength. The author uses this result to explain the facts: (1) that layers of clay are impermeable unless the head exceeds

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a certain minimum; (2) that the water contents of clays do not drop below a certain limit; (3) that a drop of water does not spread over a surface wetted by water.

Theory of surface friction.—As a result of the observations mentioned and of a new set of experiments, the author concludes that the ordinary laws of friction of rest apply only where contact between the rubbing surfaces must be enforced by outside pressure. When two even surfaces are in contact the explanation of the causes of friction is not so simple on account of the presence of small particles on the surfaces. AUTHOR.

1363. *Waves in Water.* **A. R. Richardson.** (Phil. Mag. 40. pp. 97–110, July, 1920.)—Methods are given for the solution of the flow, if a liquid under gravity with a free surface and a given form of rigid boundary. Various problems are discussed, including the flow over a weir and standing waves of elevation. W. A. R.

1364. *Method of reaching Extreme Altitudes.* **R. H. Goddard.** (Nature, 105. pp. 809–811, Aug. 26, 1920.)—The method is to use a rocket with a multiple charge, employing explosive material of as great energy-content as possible, the exploded material being shot downwards with as high a speed as possible. The propellant must form as great a fraction of the rocket as possible, and this may be achieved by feeding charges from a magazine successively into the same combustion chamber. As the magazine empties itself the above fraction decreases so that for extreme altitudes, in order to secure that at no time during the ascent the fraction shall become small, one or more rockets, copies in minature of the primary, must be used. Experiments so far have shown that most of the heat energy of the propellant can be converted into kinetic energy of the ejected gases; that a light multiple charge rocket can be made to fire several charges in succession and travel straight; and that the presence of air is not necessary for the propulsion of the rocket. In an early experiment the velocity of ejection of the gases was nearly 8000 ft. per sec., approximately the "velocity of escape" from the moon.

Further experiments are being made, at present in the direction of producing a rocket of small size for employing a large number of charges. M. A. G.

1365. *Relativity and Rotation.* **R. A. Sampson.** (Phil. Mag. 40 pp. 67–72, July, 1920.)—The author points out that in the field of mechanics the cases involving perpetual repetition, such as the earth's rotation, planetary revolutions, and periodical mechanical motions generally are those reduced to the best order. He argues, therefore, that it is in the simplest cases of circular motion that we should seek evidence of drift through the ether, and that it is not tolerable to erect a new theory, of completely general scope, leaving out of account the most familiar and best analysed types of observed events. He considers two concentric spheres differing infinitesimally in radii, with observers A and B on the outer surface of the inner sphere and the inner surface of the outer respectively, and supposes all phenomena to pass in the intervening space. A and B will have a common unit of length, the common circumference, so that they can determine the arc AB at any moment, as a fraction of this unit. Any difference will determine a definite relative rotation about an axis in the plane AB. A and B will then be under circumstances of complete geometrical relativity. But only on the assumptions of eliminating time from the observations and of the existence of figures with definite distances between the points. An aberrational allowance is therefore an inevitable attendant upon actual physical measures, and the author observes that it would not be surprising if this necessity proved fatal to such a scheme of abstract geometrical relativity. Suppose A and B, both on the equator of the uniform relative motion of the spheres, to compare clocks by time-signals, as Einstein suggested; then on relativity theory their zeros would differ by ux/c^2, where x is the length of the arc AB, u the speed of B relative to A, and c the speed of light. B would then receive two signals, generally at different times and always in opposite directions, and might therefore set two clocks by them, one slow and the other fast. One would lose and the other gain $\tau u^2/c^2$ in each relative revolution or *day*, τ being the length of the day. And the day would be a phenomenon observable both to A and B, being marked as the interval between two consecutive coincidences of B with A. B would then be able to ascertain that the times of both his clocks were erroneous, and would not require to adopt the same numerical measure of the speed of light as A, in order to provide himself with a standard measure of time. Now it has been the practice to observe at Greenwich the transit of the lunar crater Mösting A. Imagine an observer in the moon, situated in Mösting A and taking the moment when Greenwich crossed the medial line of the earth's disc—which would bring him into the meridian of Greenwich. Assuming a definite moment of occurrence of the geometric phenomenon, each observer would get it late by the same amount, about 1·3s., being the time of transmission of light; but on repeated observations each would have exactly the same time-intervals of what may be called a lunar day at his service for common standardisation of time. G. W. DE T.

1366. *A Hypothesis of Analytical Mechanics important for the Quantum Theory.* **A. Szarvassi.** (Ann. d. Physik. 60. 6. pp. 501–520, Nov. 27, 1919.)—In statistical or quanta theoretical investigations, the choice of the independent variables which serve for the construction of the phase space is only limited by the condition that these must form a canonical system. It is, however, frequently necessary to pass from one system of canonical variables to another, and Schwarzschild has shown that the transition from the original coordinates and impulses may produce angular and actional variables. The author now deals with the properties of the transformation of one system of canonical variables into another such system. The solution of this problem for astronomical purposes has long been known, viz., if x_λ, y_λ are the original, and u_λ, v_λ the new canonical variables, and the transformation equations take the form:

$$\left.\begin{aligned} x_\lambda &= f_\lambda(u_1, u_2 \ldots u_n ; v_1, v_2 \ldots v_n) \\ y_\lambda &= g_\lambda(u_1, u_2 \ldots u_n ; v_1, v_2 \ldots v_n) \end{aligned}\right\} \lambda = 1, 2 \ldots n_1$$

then the equations of condition to be satisfied are

$$(u_\lambda, u_\mu) = 0, \quad (v_\lambda, v_\mu) = 0, \quad (u_\lambda, v_\lambda) = \begin{matrix} 0 \text{ for } \lambda \neq \mu \lambda = 1, 2 \ldots n_1 \\ 1 \text{ for } \lambda = \mu \mu = 1, 2 \ldots n_1 \end{matrix}$$

the Poisson symbol,

$$(\phi, \psi) = \Sigma[n, \lambda = 1](\partial\phi/\partial x_\lambda \,.\, \partial\psi/\partial y_\lambda - \partial\phi/\partial y_\lambda \,.\, \partial\psi/\partial x_\lambda).$$

being introduced.

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The author now shows that this condition may be stated in a quite different form which is of special interest for the quantum theory, in that a fundamental property of phase space is disclosed. Let $x_1, x_2 \ldots x_n$; $y_2 \ldots y_n$ be canonical variables, whereby

$$\dot{x}_\lambda = \partial H/\partial y_\lambda, \dot{y}_\lambda = -\partial H/\partial x_\lambda \; \lambda = 1, 2 \ldots n,$$

while the Hamiltonian characteristic function is designated by $H(x_1, x_2 \ldots x_n; y_1, y_2 \ldots y_n)$. If a transition be made from x_λ, y_λ to the new canonical variables $u_1, u_2 \ldots u_n; v_1, v_2, \ldots v_n$, this obtains by means of a function $S(x_1, x_2 \ldots x_n; v_1, v_2 \ldots v_n)$. The necessary and sufficient condition that the new variables also form a canonical system is that the transformation equations take the form:

$$y_\lambda = \partial S/\partial x_\lambda, u_\lambda = \partial S/\partial v_\lambda \; \lambda = 1, 2, \ldots n.$$

The function S also contains the condition that the Hess determinant $\partial^2 S/(\partial x_\lambda \partial v_\mu)$ must be different from zero, since x_λ, y_λ should be independent of each other and also u_λ, v_λ. The canonical equations are thus invariant. The author next derives an important consequence for the quantum theory, namely, that by such a transformation of a phase space, any portion of it is transformed into one equally great. Applications are then discussed. A fundamental property of phase space is thus shown to be invariant by this transformation, viz., the volume. The author also opines that the Planck-Sommerfeld extension of the quantum theory to n degrees of freedom may have its basis in equations of the form here discussed. H. H. Ho.

1367. *Motion of an Elongated Spheroid in Viscous Fluid Media.* **B. Pal.** (Calcutta Math. Soc., J. 11. pp. 43–50, Sept., 1920.)—Mathematical treatment of the motion along the axis of the spheroid.

1368. *Building-up of Atoms.* **E. Rutherford.** (Engineering, 110. p. 382, Sept. 17, 1920. Paper read before the British Assoc., Cardiff, Aug., 1920.)—An outline description is given of recent developments in the theory of the structure of atomic nuclei. The paper refers to a continuation of the researches described in the Bakerian lecture [see Abs. 1227 (1920)] relative to the emission of He and H atoms from nuclei and the deflection of α-particles fired into close proximity with the nuclei. The present discussion deals with the ultimate structure of atomic nuclei; suggestions are put forward that H_1, H_3, and H_5 atoms may be the "bricks" of the complete structure. A. B. W.

1369. *Structure of Atoms and its bearing on Chemical Valency.* **I. Langmuir.** (J. Indust. and Eng. Chem., April, 1920. Chem. News, 121. pp. 29–32, July 16, 1920.)—From the atomic numbers of the inert gases it is possible to determine the numbers of electrons in the various layers, or shells of electrons, existing in the atoms. Thus the xenon atom with the atomic number 54 contains 54 electrons arranged as follows: Close to the nucleus are two electrons constituting the first shell, which is surrounded by the second shell containing two "layers" of eight electrons each, while the third and for xenon outside shell contains eighteen electrons. Hence the numbers of electrons in the successive layers are related as the squares of the integers, *i.e.*, 1, 4, 9, 16, etc.; it is noteworthy that these numbers play a prominent part also in Bohr's theory of the atom.

The foregoing theory of the arrangement of electrons in atoms explains the general features of the entire periodic system of the elements and is successful especially in accounting for the position and properties of the so-called eighth group and the rare-earth elements; it serves likewise to correlate the magnetic properties of its elements.

As regards the bearing of this theory of atomic structure on the phenomena of chemical valency, the outstanding feature of the theory is that there are certain groups of electrons, such as the pair in the first shell and the octet in the second, that have remarkable stability. Those atoms in which all the electrons form parts of such stable groups, viz., the inert gases, will have no tendency to change the arrangement of their electrons and will thus not undergo chemical change. If, however, an atom of fluorine (atomic number 9) and an atom of sodium (11) are brought together, ten electrons are needed for the stable pair in the first shell and the octet in the second shell, as in the neon atom. Since the sodium atom has one more, and the fluorine atom one less, electron than is required to give this stable structure, it is obvious that the extra electron of the sodium atom should pass over completely to the fluorine atom. The sodium atom is thus left with a single positive charge, while the fluorine becomes negatively charged, and if the two charged atoms or ions were alone in space they would be drawn together by electrostatic force and would move as a unit and thus constitute a molecule. If other sodium and fluorine ions are brought into contact with the " molecule " they will be attracted as the first one was, and there will result (at not too high a temperature) a space lattice consisting of alternate positive and negative ions and the " molecule " of sodium fluoride will have disappeared. This is just the structure found experimentally for sodium fluoride by Bragg's method of X-ray crystal analysis; there are no bonds linking individual pairs of atoms together, and the salt is an electrolytic conductor only in so far as its ions are free to move, so that in the molten condition or in aqueous solution it becomes a good conductor. The case of magnesium ($N = 12$) and oxygen ($N = 8$) is similar, except that two electrons are transferred, and the crystalline forms of magnesiun oxide and sodium fluoride should be identical, as is actually found to be the case by the X-ray method. Other examples are given.

As a result of the sharing of electrons between octets, the number of octets that can be formed from a given number of electrons is increased. If e represent the number of electrons in the outside shell of the atoms that combine to form a molecule, n the number of octets formed from these e electrons, and p the number of pairs of electrons which the octets share with one another, it follows, since every pair of electrons thus shared reduces by two the number of electrons required to form the molecules, that $e = 8n - 2p$ or $p = \frac{1}{2}(8n - e)$; this equation is applicable to compounds of all types.

This theory indicates a series of new relationships between certain types of substances which have been termed " isosteric." Thus it indicates that the molecules of carbon dioxide, nitrogen dioxide, and nitrous oxide should have almost identical structures, this being borne out by the great similarity in the physical properties; nitrogen and carbon monoxide constitute another such pair. T. H. P.

1370. *Size of Atoms.* **A. Landé.** (Zeits. f. Physik, 2. 1. pp. 87–89, 1920.)—In a previous paper [see Abs. 1130 (1920)] the author has discussed the same subject. Making use of the known cubical structure possessed by positive alkali ions and negative halogen ions in combination, and taking note of the e.m.f.'s called into play in the union, the author has deduced the radii of the respective ions. The values given in the following table are stated to be a few per cent. greater than the exact values.

$a_0 = 0{\cdot}528 \times 10^{-8}$ cm.	Na+.	K+.	Pb+.	Cs−.	F−.	Cl−.	Br−.	I−.
r/a_0	2·07	2·73	3·10	3·01	2·26	3·10	3·38	3·86

These values are now confirmed from considerations of spectroscopic evidence. A. B. W.

1371. *Dynamics of Spacial Atomic Structure.* **A. Landé.** (Zeits. f. Physik, 2. 1. pp. 83–86, 1920.)—A continuation of previous papers on the same subject [see Abs. 684 (1919) and 501 (1920)]. No concise abstract is possible. A. B. W.

1372. *Crystal Structure.* **A. Reis.** (Zeits. f. Physik, 2. 1. pp. 57–59, 1920.)—Observations relating to a previous paper by the author, entitled "On the Knowledge of Crystal Structure" [see Abs. 1131 (1920)]. A. B. W.

1373. *Crystal Gratings in which the Atoms are held in Stable Equilibrium by Gravitational Forces.* **R. Schachenmeier.** (Ann. d. Physik, 60. 6. pp. 548–569, Nov. 27, 1919.)—A mathematical paper not permitting of a short abstract. A. B. W.

1374. *Theory of Structure of Zincblende.* **M. Born** and **E[lisabeth] Bormann.** (Ann. d. Physik, 62. 3. pp. 218–246, June 8, 1920.)—A mathematical paper which should be consulted in the original. A. B. W.

1375. *Intensity of Nocturnal Radiation at Elevated Stations.* **A. Boutaric.** (Comptes Rendus, 170. pp. 1195–1196, May 17, 1920.)—The author has previously shown [Thesis, Paris, 1918] that the intensity (r) of nocturnal radiation in clear weather can be expressed by $r = n\sigma\theta_0{}^4\text{F}(f_0)$, where θ_0 is the absolute temperature of the black radiating surface and f_0 the pressure of water-vapour near the surface. It is now pointed out that the formula does not introduce the barometric pressure and, according to the theory previously developed, nocturnal radiation should be sensibly the same at any two altitudes for the same pair of values of θ_0 and f_0. A practical test of this is made, using the high-level station on the Pic-du-Midi (2859 m.) and comparing the observations with those originally made at Montpellier, practically at sea-level, with results which appear to confirm the deduction made. M. A. G.

1376. *Electric Oscillation Anemometer.* **E. Rothé.** (Comptes Rendus, 170. pp. 1197–1198, May 17, 1920.)—In cloudy or foggy weather, when observations of the upper winds by pilot-balloons are impossible, an electric contact anemometer may be raised by balloon or kite, but this necessitates a double wire with the consequent additional weight to lift. The author outlines a method using only a single wire, the cable of the

balloon or kite. The anemometer is made to act as an interrupter putting into action, at each contact, an instrument which sets up electric oscillation in the wire. These are received at the surface by a "wireless" receiving set. The velocity of the wind is deducible in the ordinary way from the frequency of the contacts. Several anemometers may be attached to the cable at different heights, each instrument emitting waves of a different length, so that any particular one may be made to register by suitably tuning the receiver at the surface. Extension might be made to other meteorological elements, and a complete "observatory" could then be raised and made to record at the surface by a single wire.
M. A. G.

1377. *Colour and Polarisation of Sky Light.* **A. Gockel.** (Ann. d. Physik, 62. 3. pp. 283–292, June 8, 1920.)—Using a polarimeter fitted with Wratten filters, the polarisation of the light from the sky is investigated for various parts of the spectrum. The intensity of the light was also measured after each observation of polarisation. In the paper the results and methods of other authors are fully discussed, but the writer's own results are chiefly that in a clear atmosphere the differences in the polarisation of individual colours are smaller than the errors of observation. With increasing turbidity, however, the polarisation in the short wavelengths exceeds that in the long, but where, through diffraction, little or no blue can originate, as in the neighbourhood of the sun and in a damp layer, the excess is with the long-wave part of the spectrum.
M. A. G.

1378. *Search for a New Atmospheric Gas.* **C. Borel** and **A. Jaquerod.** Archives des Sciences, 2. p. 265, May–June, 1920. Paper read before the Soc. Suisse de Physique.)—Although there is apparently no room for an unknown gas among the elements, the authors wished to ascertain whether certain auroral lines, notably 557, were possibly due to an atmospheric constituent. They tried diffusion through quartz. In the first series of experiments ordinary air was heated in a quartz vessel to 350°; the diffused gas was drawn off every day. After two months 1 cm. of gas was collected which gave the spectrum of helium and, less brilliantly, also hydrogen and neon lines, but no new lines. In the second series an air-liquefaction residue, received from G. Claude, was fractionated; the helium portion was then twice diffused through hot quartz. No other gas was found.
H. B.

1379. *Great Red Spot on Jupiter.* **W. F. Denning.** (Nature, 105. pp. 423–424, June 3, 1920.)—Since 1878, when this object attracted general observation, its rotation period slowly lengthened till 1900. In 1901 the large irregular S. tropical spot appeared with a rotation period 23 secs. faster, and whenever it has overtaken the red spot since then it has acclerated its rotation.

Mean period 1894–1901 .... 9h. 55m. 41·3s.
Mean period 1912–1919 .... 9h. 55m. 35·7s.

This S. tropical spot seemed to be fading out in 1918, but has since revived. It is of a different character to the red spot which still keeps its oval form, while the S. tropical spot is irregular and variable
W. W. B.

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1380. *Brightness of the Night Sky.* **G. J. Burns.** (Astrophys. J. 52. pp. 123–126, Sept., 1920.)—*Brightness of the night sky; a discussion of the various determinations.*—Although the large discrepancies indicate that some unknown sources of error have not been eliminated, the author suggests that close agreement can hardly be expected because of the individual peculiarities of observers' eyes, and because of the effect of varying atmospheric conditions. AUTHOR.

1381. *Perturbations of the Orbit of the Spectroscopic Binary* 13 *Ceti.* **J. S. Paraskévopoulos.** (Astrophys. J. 52. pp. 110–122, Sept., 1920.)—*Triple system* 13 *Ceti.*—This interesting system is a visual binary with a period of 6·88 years whose brighter component is a spectroscopic binary with a period of about 2 days. During the seasons 1906–1907, 1908, and 1912–1913, 39 plates taken with the Bruce spectrograph at Yerkes Observatory have enabled the mean *elements of the orbit of the spectroscopic binary* to be determined for each of the three periods. These clearly show *perturbations due to the fainter visual component.* The period is shorter near apastron than near periastron. The eccentricity and $a \sin i$ show only slight variations but the precessional motion of the line of apsides is well established. The results enable the *relative masses of the components of the visual binary* to be computed approximately and indicate that the mass of the fainter component is probably at least as great as that of the brighter one. The *sign of the inclination of the orbit of the visual binary* is shown to be positive. AUTHOR.

1382. *Application of Michelson's Interferometer Method to the Measurement of Close Double Stars.* **J. A. Anderson.** (Mt. Wilson Observat. Contrib. No. 185. Astrophys. J. 51. pp. 263–275, June, 1920.)—*Michelson interference method of measuring close double stars.* It is surprising that this method of accurately measuring angles as minute even as half the limit of resolution of the telescope used has heretofore been applied only to Jupiter's satellites. But after Michelson found by tests last year at the Yerkes Observatory and at Mount Wilson that clear and relatively steady fringes can be obtained even when the "seeing" is bad, steps were taken to apply the method to the measurement of the separation of the components of Capella. The *arrangement of apparatus* adopted is described in full. The apertures were placed near the focus instead of at the objective and set at a fixed distance apart, somewhat greater than the distance for minimum visibility, and were then rotated and the four position angles which gave minimum visibility were determined. After the *effective wave-length* for a G-type star had been found by laboratory experiments with sunlight to be about 0·550 μ, the position readings gave both the angular separation of the components and the direction of the line joining them. The *effect of atmospheric dispersion* is in general to shift the centre of the system. Two methods of compensating for this effect are suggested. A method of determining the *relative brightness of components* when the ratio is not more than 1·5 is described and illustrated.

Accuracy.—In the case of Capella, the separation, about 0·05″, was determined within 1 %. As to the *limits of applicability of the 100-in. reflector* in such measurements, the theoretical resolution limit with the interferometer is 0·025″, and double stars down to about the eleventh magnitude should be measurable under ordinary observing conditions.

Elements for Capella as determined by the Michelson interference method.—Observations made on six dates, December 1919 to April 1920, give the following results: $a = 0{\cdot}05249''$; T = J.D. 2422387·9; $i = 140° 30'$. These combined with spectroscopic elements give: P = 104·006 days; $a_1 + a_2 = 130{,}924{,}000$ km.; $m_1 = 4{\cdot}62 \odot$; $m_2 = 3{\cdot}65 \odot$.

Interference method of measuring atmospheric dispersion, by its effect on the fringe systems of stars at various zenith distances, is suggested by the author as likely to prove very sensitive. AUTHOR.

1383. *Photographs of Nebulæ with the 60-in. Reflector*, 1917–1919. **F. G. Pease.** (Mt. Wilson Observat. Contrib. No. 186. Astrophys. J. 51. pp. 276–308, June, 1920.)—*Photographs of nebulæ with the 60-in. reflector.*—About 330 of the nebulæ found on the 66 plates taken by the author during the years 1917–1919 are listed or described in this article, and 27 of these are illustrated. The most remarkable are: N.G.C. 2146, Camelopardus, with its handlike dark marking, a spiral with an abnormal centre; N.G.C. 3379, resembling an unresolved star cluster; N.G.C. 3384, with a dual, Saturn-like nucleus and symmetrical wings; N.G.C. 4395–4399—4400–4401, which together form a remarkable spiral; N.G.C. 4656–4657, which constitute a single right-handed spiral without a well-defined nucleus; and I.C.II 5146 Cygnus, a unique array of light and dark markings.

Spectra of two nebulæ.—N.G.C. 1700 is of type Go or later and has a large radial velocity. The spectrum of the nucleus of N.G.C. 3379 is Go or later and the radial velocity is +850 km per sec. AUTHOR.

1384. *The Ellipsoidal Variable Star, π^5 Orionis.* **J. Stebbins.** (Astrophys. J. 51. pp. 218–222, May, 1920.)—The *light-curve* for this variable has been determined with reference to π^4 Orionis by a series of observations made with a photoelectric photometer in 1916–1918. The results, corrected for atmospheric extinction, show that this star is a continuous variable with a double period equal to the time of revolution in the spectroscopic orbit, 3·70 days. No eclipses are apparent. The evidence indicates that the variation is due entirely to the ellipsoidal shape of the components, resulting from their mutual attraction. The elongation of the brighter component, computed from the amplitude of light variation, must be something more than 5 %. This is the first case where ellipsoidal variation unaccompanied by eclipses has been detected by the author.

Spectroscopic binary, π^4 Orionis.—The photoelectric photometric observations indicate that the *light variation* of this binary is very small or nil. AUTHOR.

1385. *The Eclipsing Variable Star, λ Tauri.* **J. Stebbins.** (Astrophys. J. 51. pp. 193–217, May, 1920.)—*Photometric study.*—Two series of observations made with a sensitive photoelectric photometer during 1916–1917 and 1917–1918 have enabled the *light-curve* of this third-magnitude star to be determined. It is found to be a normal eclipsing system with two minima and continuous variation between eclipses. A comparison of the times of minima with those computed from spectroscopic studies shows a satisfactory agreement. *No light effect due to the third body*, whose existence was shown by Schlesinger to account for the observed spectroscopic orbit, is clearly evident, although a few observations, discordant up to 0·1 mag., occurred at such dates as to suggest they might be caused by this body. Because of the undetermined light of the third body and because of the small range of about 0·4 mag. in a partial eclipse, *the elements for this system* can be determined, as yet, only roughly. Plausible values for the *sizes, densities,* and relative *brightness,* of the bodies, and for the *inclination* and *ellipsoidal constants,* are given. The *difference in brightness of opposite sides of the second body* is probably chiefly due to the heating effect of the intense radiation from the first body. The author calls attention to a systematic discrepancy of 0·01 mag. between the two series of observations of 1916–1917 and 1917–1918, which is unexplained.

Stars of Class B, π^1 Orionis, ξ Tauri, ϵ Tauri, μ Tauri.—These stars were used for comparison in the above series of photoelectric measurements and none was observed to vary by as much as 0·05 mag., although variables are common in this class.

Photoelectric photometer for stellar observations.—After a large number of trials, a potassium photoelectric cell of fused quartz has been developed which makes the photometer much more sensitive than the former selenium photometer and which enables sixth-magnitude stars to be studied with a 12-in. telescope. AUTHOR.

1386. *Spectrum of Nova Ophiuchi,* 1919. **W. S. Adams** and **C. G. Burwell.** (Mt. Wilson Observat., Contrib. No. 179. Astrophys. J. 51. pp. 121–126, March, 1920.)—The paper reports in detail *measurements* of a spectrogram obtained with the 100-in. reflector on 1919 Nov. 2. Although the star had reached its max. brightness over six weeks before, the general features of the spectrum are characteristic of novæ at a comparatively early stage of development. The strong continuous background is crossed by bright bands, with absorption lines forming their violet edges, which correspond mainly to hydrogen and calcium lines and to the enhanced lines of Fe and Ti. The middle of each band is displaced about 1 Å. to the red, while the absorption lines are displaced from 4·5 to 5·5 Å. to the violet. The shifts for the various lines are proportional to the wave-length and are about half the width of the associated bands. The *radial velocity* indicated by the calcium absorption lines is about +6 km.

Spectra of novæ; a simple interpretation of the observed displacements.—The fact that for Nova Persei, Nova Geminorum No. 2, Nova Aurigæ, and Nova Ophiuchi the displacement of the absorption lines is in each case about twice the width of the corresponding bands, suggests that both phenomena are mainly Doppler-effects and lends some support to the *hypothesis* of a shell of gas moving rapidly out from each star. AUTHOR.

1387. *Studies Based on the Colours and Magnitudes in Stellar Clusters.* XVII. *Miscellaneous Results.* **H. Shapley.** (Mt. Wilson Observat., Contrib. No. 190. Astrophys. J. 52. pp. 73–85, Sept., 1920.) —*Discovery and position coordinates of* 88 *variable stars in globular clusters* N.G.C. 5024, 6293, 6553, 6779, 6864, 6981, 7006, and 7492 are collected in Table II in the original.

Absolute visual magnitudes of forty globular clusters are given in Table III. More than half lie within the interval −8·3 to −9·3, the mean being −8·8±0·5. This remarkable agreement in absolute magnitude enables parallaxes to be estimated from the apparent brightness with a probable error of less than 25 %. The *total light-emission of an average cluster* is about 275,000 times that of the sun.

Galactic cluster N.G.C. 7789 is found from the count of 13,500 stellar images to contain about 1100 stars with magnitudes ranging from 13 to 20. The probable linear diameter is 20 parsecs.

Theoretical conclusions regarding Cepheid variables.—Assuming the average heat content per unit mass and therefore the ratio of mass to radius to be the same for all these variables, the author derives a theoretical period-luminosity curve which fits the observations well if the mean atomic weight has the value indicated by other considerations, viz., between 2·5 and 3·0. This agreement lends support to the theory and to the conclusion that only giant stars with a particular ratio of mass to radius become Cepheid variables.

Globular cluster N.G.C. 7006 is so distant that the faintest stars recorded on the plate, magnitude 20, are probably a hundred times as bright as our sun. The star count indicates that the cluster is similar in constitution to nearer ones.

Density of stars in galactic longitude +32° *and latitude* —20°, to photographic magnitude 20, is about 23,000 per square degree. AUTHOR.

1388. *Orbits of the Spectroscopic Components of Boss* 5026. **W. E. Harper.** (Astrophys. J. 51. pp. 187–189, April, 1920.)—*Spectroscopic binary Boss* 5026 (mag. 6·3; type F5). A series of twenty-nine plates secured during the summer has enabled the *elements of both orbits* to be determined with considerable accuracy. The results are given in a table and are also shown graphically. The period is 7·638 days; the *masses* are nearly equal, 1·854 and 1·827.; the *velocity of the system* is about —15·6 km. AUTHOR.

1389. *Five Oe5 Stars with Variable Radial Velocities.* **W. C. Rufus.** (Astrophys. J. 51. pp. 252–254, May, 1920.)—*Class Oe5 stars with variable radial velocities.*—As in the case of most of the stars of this spectral class which have been investigated, it has been found that 9 Sagittæ, A Cygni, B.D. + 37° 1146, B.D. + 44° 3639, and B.D. + 56° 2617, have variable velocities and therefore probably belong to binary or multiple systems. Measurements of twenty-nine plates, scattered over a period of several years, are given in a table and show variations for the different stars amounting to from 20 to 160 km./sec., variations which are from 8 to 60 times the probable error. In addition, variations of about 10 km./sec. were found for B.D. + 52° 726 and 19 Cephei. AUTHOR.

1390. *Early Spectrum of Nova Aquilæ No.* 3. **A. L. Cortie.** (Observatory, 43. pp. 229–230, June, 1920.)—From a comparison of the evidence afforded by plates taken on June 9 and 10, 1918, the author concludes that the doubling of the dark hydrogen bands, assumed concomitant with the first appearance of the bright band spectrum, must have come between Evershed's photograph June 10, 6h. 30m. G.M.T., and the Stonyhurst photograph commencing June 10, 11h. 0m. G.M.T. He finds corroborative evidence in support of Stratton's contention that the successive phases of spectral change are due to a series of pulses. After the third pulse (June 15), the spectrum began to approximate to a B type. W. W. B.

1391. *Spectrum of Nova Aquilæ No. 3.* **J. Lunt.** (Roy. Astron. Soc., M.N. 80. pp. 696–709, June, 1920.)—This is the continuation promised in a previous paper [Abs. 979 (1920)], and deals with the changes noted when the star came under observation again in 1919. In particular it deals with the structure of the bright nebular band, λ4363; with the pair of strong dark lines at λλ4054 and 4060, seen in 1918; with the H and K lines of Ca, and the bright He band λ4471·6 and its associated dark lines. There is a dark line displaced about 450 km./sec. to the violet which persists through the whole series of spectra. The author is inclined now to prefer the idea of Adams and Evershed that the indicated velocities are real and due to matter ejected with explosive force, rather than his own previous suggestion of a high-velocity star from without penetrating a nebula. He also discusses the rate of expansion to a planetary nebula of measurable disc, comparing it with van Maanen's list of planetary nebulæ, but further measures must be awaited, as the rate deduced would demand an expansion of 15″ annually, if van Maanen's parallax is accepted, and this is not in agreement with observation.

W. W. B.

1392. *Distribution of the Stars in Space in High Galactic Latitudes.* **J. C. Kapteyn** and **P. J. Van Rhijn.** (Mt. Wilson Observat., Contrib. No. 188. Astrophys. J. 52. pp. 23–38, July, 1920.)—*Distribution of stars in space.*—While the results reported in this paper are provisional, in that some recently available parallaxes are not included and the investigation of the lower galactic latitudes has not been completed, it is unlikely that more complete data will materially modify them. (1) *In galactic latitudes* ± 40° *to* ± 90°. The *average parallax for all stars of a given magnitude* (m) *and proper motion* (μ) is found to be represented satisfactorily by the formula $\log \pi = -0\cdot691 - 0\cdot0682\, m + 0\cdot645 \log \mu$. By combining this result with the law of dispersion of parallax for stars of given m and μ, which had already been determined, the two fundamental laws which determine the arrangement of stars in space were found. The first of these is the *luminosity-curve*, or frequency of the several absolute magnitudes per unit volume, which, at least near the sun, is found to correspond accurately, from $-10\cdot6$ mag. to $+7\cdot4$ mag., to a symmetrical probability-curve with the equation: $\log \phi(M) = -2\cdot394 + 0\cdot1858M - 0\cdot03450M^2$. Assuming that the luminosity-curve is the same for all distances from the sun, the median absolute magnitude of all stars is 2·7 (which is about 2·9 mag. fainter than the sun), with a probable error of ± 1·69 mag. The second law is the *law of stellar densities* as a function of parallax. For distances below 1000 parsecs the densities can be determined directly. For greater distances the following formula was derived from the luminosity-curve and the distribution-curve of apparent magnitudes, assuming no extinction of light in space: $\log \Delta(\rho) = -3\cdot425 + 3\cdot526 \log \rho - 0\cdot943 (\log \rho)^2$. (2) *In galactic latitudes* 0°, 30°, 60°, *and* 90°. A less refined investigation of all stars in these latitudes has led to formulæ for the densities as a function of parallax which are similar to that given above. These results enable us to draw a *section of the galactic system* at right angles to the galactic plane, with the sun at the centre, which shows that in the direction of the galactic poles about 1500 parsecs may be taken as practically the limit of the system, while in a direction in the plane of the Milky Way the same small density is eight times more distant. The authors point out that, since symmetry around the galactic poles is assumed, this work is merely a second approximation to the complete solution of the problem. AUTHOR.

1393. *Studies Based on the Colours and Magnitudes in Stellar Clusters.* XVI. *Photometric Catalogue of* 848 *Stars in Messier* 3. **H. Shapley and H. N. Davis.** (Mt. Wilson Observat., Contrib. No. 176. Astrophys. J. 51. pp. 140–178, April, 1920.)—*Globular cluster Messier* 3.—The paper reports in detail measurements of 14 photographic plates taken at the primary focus of the 60-in. reflector during 1915 and 1917. Table II is a *photometric catalogue of* 848 *stars*, giving the photographic and photo-visual magnitudes and the colour-index of each. Of these stars, 750 are suitable for statistical work. The known variables are omitted, but it appears from a comparison of the different plates that at least 17 others are probably *variable stars*. As for the *distribution of stars of various magnitudes and colour-type*, a statistical study of the measurements shows that stars of all types and magnitudes are very well mixed, at least for angular distances from the centre greater than 2′. The *spectral curve*, omitting variables, shows a maximum frequency near colour-class *f*5 and differs from the corresponding curve for Messier 13 in being without a secondary maximum for the blue stars. The *magnitude curve* shows a maximum frequency for photo-visual magnitude 15·5 which is near absolute magnitude zero, as computed on the basis of the previously determined *parallax* of 0·000072″; the curve, as usual, is far from being symmetrical. The *relation of colour-index to magnitude* shows the usual decrease of index with decreasing brightness. In general these results corroborate those yielded by the previous analysis of Messier 13. The *position coordinates of* 370 *stars* which were not listed by v. Zeipel are given in Table III. AUTHORS.

1394. *Temporary Shifting Absorption at the Heads of Helium Bands in the Spectrum of γ Argus.* **C. D. Perrine.** (Astrophys. J. 52. pp. 39–46, July, 1920.)—*Variations in the spectrum of γ Argus.*—The author has previously called attention to a quasi-periodic change in the H_β line of this Wolf-Rayet star. Observations continued during 1917–1919 have confirmed this result and led to the discovery of the appearance, during four short periods, of one or two *temporary, shifting, absorption lines* on the violet sides of the bright *e* bands at λλ3820, 3889, 4026, 4471, and 5016. The shifts of corresponding lines are proportional to the wave-length and indicate absorption by a radially expanding shell of gas whose speed in two cases increased within two or three weeks to a limit of about 1380 km., while in another case it decreased somewhat. Besides these measurable absorption lines there were other fainter ones on both the red and violet sides of the bands. During one active period two other bands, λλ4650 and 5690, showed absorption lines, but the shifts were constant and relatively greater than those just mentioned. The hydrogen bands showed no absorption lines. These results suggest great activity on the surface of the star. AUTHOR.

1395. *The Colour of the Nebulous Stars.* **F. H. Seares and E. P. Hubble.** (Mt. Wilson Observat., Contrib. No. 187. Astrophys. J. 52. pp. 8–22, July, 1920.)—*Colour of forty-seven nebulous stars.*—The ratio of the times of exposure with and without a yellow filter, producing images of the same size on an isochromatic plate, varies regularly with the spectral type for normal stars of a given absolute magnitude. Most nebulous stars, however, as the results in this paper show, are abnormally red for their spectral type. The colour-indices of thirty-six out of the forty-two nebulous stars for which complete data are available are from 0·4 to about 3 colour-classes in advance of their respective spectral types. The average *colour excess* is about one colour-class, which is five times the probable error. Two methods were used. The colour-indices obtained from the *blue-yellow exposure ratios* determined with the 60-in. reflector were checked in part by those obtained from *polar comparisons of photographic and photo-visual magnitudes* made with the 10-in. Cooke refractor. The stars investigated are in R.A. 6h. to 7h. and 16h. to 18h. and include among others ρ Ophiuchi, ρ Scorpii, 22 Scorpii, N.G.C. 1514, 2170, 2175, 2182, 2245, 2247, 2282, 2283, I.C. 444, 446. Several possible *explanations* of these results are discussed.

Suspected variable star.—The behaviour of B.D. + 10° 1771, 8·0 mag., spectrum Ko, suggests that it may be a variable.

Spectrum of nebulosity around nebulous stars N.G.C. 2245, 2247, 2282, I.C. 446, and ρ Ophiuchi is continuous, whereas the nebulosity around N.G.C. 1514 is gaseous. AUTHORS.

1396. *Systematic Motions of Stars derived from Radial Velocities.* **J. Halm.** (Roy. Astron. Soc., M.N. 80. pp. 682–692, June, 1920.)—Analysis of the computed radial motions of 1888 stars provides the author with evidence in support of his theory that the distribution of the stars in space is not altogether random, nor is it satisfactorily explained on Kapteyn's "two-stream" hypothesis, nor on Schwarzschild's ellipsoidal theory, but that a third stream or rather a residuum of stars not belonging to either of the two streams of Kapteyn's theory; but distributed practically at random, is necessary: the three classes thus postulated account satisfactorily for all stars. The author considers the two drifts to be chiefly local near the solar system and that most of the distant stars belong to the third or O class. [See Abs. 1450 (1911).] W. W. B.

LIGHT.

1397. *Simple Non-intermittent Exposure Machine.* **G. I. Higson.** (Phot. J. 60. pp. 235–237, June, 1920.)—Various types of non-intermittent exposure machines have already been described by Jones [see Abs. 571 (1920)], but these are somewhat complicated, being intended for rapid and systematic working. An attempt was therefore made to design a simple apparatus for experimental purposes which would be easily adaptable for many variations in the time of exposure. A detailed account of such a machine and of the method of illumination employed is given. The machine is at present in regular use for experimental purposes, but the investigations are not yet complete. A. E. G.

1398. *New Apparatus and Measurements in the Infra-Red.* **H. Witt.** (Phys. Zeits. 21. pp. 374–378, July 15, 1920.)—Describes a radiomicrometer of great sensitivity, and a mirror spectrometer of simplified construction, with which the absorption of water-vapour can be obtained directly in the region 80 to 160 μ. The radiomicrometer, of which a photograph is given, is similar in principle to Boys' type of instrument, and special precautions were taken to ensure that the moving system (including thermo-element, mirror, etc.) was entirely non-magnetic. The spectrometer made use of a specially constructed wire grating. For this grating silver wire was used of diam. about 0·17 mm. The wire was wrapped round a frame 4 cm. by 3 cm., the wires secured with Rose's metal, and those at the back cut away, leaving a grating whose constant was found to be 0·3000 mm. The grating was arranged with various mirrors to serve as a spectrometer, and gave good results in the region 80 to 160 μ. Various curves are given showing the results obtained for the emission from incandescent burners coated with various cerium-thorium mixtures. For the 5 % Ce, 95 % Th mixture a sharp peak is obtained at about 128 μ. For 100 % Ce there is a gradual rise from 160 μ to a maximum at about 142 μ, when there is a sharp drop to a minimum value at about 138 μ, followed by a second maximum (not so great as the first), at about 130 μ. For 100 % Th maxima are found at about 142 μ, 130 μ, and 114 μ, with minima at 138 μ and 125 μ. A further series of measurements with the Th burner showed that the minima observed corresponded with many of the absorption bands of water-vapour. A curve given shows minima at 125 μ, 106 μ, 91 μ, and at about 82 μ; and the curve shows a continuous drop from 142 μ to 160 μ, which was the limit of the measurements. The results of Miss E. v. Bahr indicate water-vapour absorption lines at 172, 124, 109, 92, and 79 μ, most of which are in good agreement with the results now given. A. W.

1399. *Measurement of Absolute Reflecting Powers.* **A. H. Taylor.** (Optical Soc. of America, J. 4. pp. 9–23, Jan., 1920. El. World, 76. pp. 467–469, Sept. 4, 1920.)—In the introductory portion of the paper the author describes previous methods of attempting the measurement of the reflecting powers of surfaces, most of which assume the use of the integrating globe. The reflecting power of magnesium carbonate has been determined as 88 %, but this is considered too low. A new method now described utilises an integrating globe with white interior surface. An aperture is made to allow a narrow beam of light to pass into the globe, and opposite this aperture the globe is cut away so that any surface to be tested may be substituted. The observation window is placed in a line perpendicular to the direction of this beam. The theory of the apparatus is then discussed and equations are derived enabling the absolute reflecting power of the inner surface of the globe and that of the test-surface to be ascertained. In order to verify the theory the author prepared a series of surfaces of progressively darker tints by mixing black drawing ink and lamp-black with a white cement. The coefficients of reflection of this series of surfaces, and also that of magnesium carbonate, were ascertained first by point-to-point measurement, and then by two methods involving the use of the apparatus described. The results show good agreement and confirm the value previously ascertained for the reflecting power of magnesium carbonate, namely, near 99 %. The use of the apparatus with surfaces exhibiting some specular reflection is also discussed. J. S. D.

1400. *The Change of the Refractive Index with Temperature.* **E. O. Hulburt.** (Astrophys. J. 51. pp. 223–229, May, 1920.)—*Dispersion formula involving temperature, according to a modified electron theory.*—Various observers have found that the decrease of refractive index with increasing temperature is approximately linear. To explain this fact, the author has modified the Lorentz dispersion formula by introducing the *assumption* that, for the range of spectrum involved, the variation with temperature is determined by electrons of a single type, upon which the medium acts only with a *restoring force which increases linearly with the absolute temperature*, as is to be expected from the law of equipartition of energy. The new formula has four arbitrary constants. The *agreement with observed results* for a number of transparent liquids is within 0·2 % for a considerable range of wave-length and temperature and clearly indicates that the above assumption is a step in the right direction, though it is too simple to correspond accurately with the facts. AUTHOR.

1401. *Optical Constants of Liquid Alloys.* **H. A. Wilson.** (Phys. Rev. 15. p. 317, April, 1920.)—A note on a paper by C. V. Kent [see Abs. 1417 (1920)].

1402. *Velocity of Light in Moving Bodies.* **O. Knopf.** (Ann. d. Physik, 62. 5. pp. 389–447, July 8, 1920.)—This paper gives a full description of research carried out in 1909–11 by the late F. Harress on the velocity of light in a set of prisms rotating at high speed. The prism system consisted of 10 prisms, 8 of which were identical in shape, the other two being of such a shape that light passing from the centre of the prism system, after reflection from a face of one of the two latter prisms, passed through the whole train of prisms (arranged in a polygon of 10 sides) undergoing one internal reflection from the outer face of each prism, and was finally reflected from a face of the last prism to emerge on a parallel path to that of the incident beam. A special prism system on the central axis served to split the incident beam from the light source into two parts, which traversed the prism system in opposite directions, and finally interfered along the same path. The prism system could be rotated about its axis at speeds of from 1500 to 2000 revs. per min.

A full description, with numerous diagrams, is given of the optical arrangements and mechanical details of the apparatus. The formula derived for the displacement of the interference bands was $\Delta = 2lqn^2(1 - x)/\lambda c$, where c is the velocity of light in free space, q the velocity of the moving medium, n the refractive index of the substance, l the length of the path of the light in the moving body, and λ the wave-length in free space of the light used. Putting $x = 1 - 1/n^2$ according to Fresnel's theory, we have $\Delta = 2lq/\lambda c$; so that if Fresnel's theory is correct there should be no displacement of the interference bands. According to Lorentz's theory $x = [(n^2 - 1)/n^2] - \lambda/n \,.\, dn/d\lambda$. Discussion of the results leads to the final mean values $x_{625} = 0\cdot590 \pm 0\cdot0013$ and $x_{535} = 0\cdot577 \pm 0\cdot0018$. For the glass used by Harress, the following values have been calculated by Harzer:

(1) For the green light used, $1 - 1/n^2 = 0\cdot5977$, and $1 - 1/n^2 - \lambda/n \,.\, dn/d\lambda = 0\cdot6210$. (2) For the red light used, 0·5952 and 0·6120. Various considerations lead to the conclusion that the experimental results are somewhat too low, and it is considered that the experiments should be repeated. A. W.

1403. *Velocity of Light in Moving Bodies.* **M. v. Laue.** (Ann. d. Physik, 62. 5. pp. 448–463, July 8, 1920.)—This paper gives a mathematical investigation of the problem with which the research of Harress [see preceding Abs.] is concerned, in the light of the theory of relativity and the Lorentz transformation. The author concludes that little can be learned from the results obtained up to the present, and that it is very desirable the research should be repeated. [See Abs. 1506 (1914).] A. W.

1404. *Radiation-Pressure on Electrons and Atoms.* **L. Page.** (Astrophys. J. 52. pp. 65–72, Sept., 1920.)—*Assuming the classical electrodynamic equations,* the author shows (1) that the radiation-pressure on a Lorentz electron is three times the pressure on a perfectly reflecting plane normal to the radiation, and (2) that the mean pressure on a large number of linear simple harmonic atomic oscillators oriented at random is chiefly a resonance pressure. It is a function of the ratio of wave-length to atomic diameter and of the natural frequency of the oscillators, such that the pressure of solar radiation at the surface of the sun is greater than the gravitational attraction for the lighter atoms if they have one or more resonant frequencies between wave-lengths $0\cdot3\,\mu$ and $10\,\mu$. These calculations show that classical electrodynamics is competent to *explain observed phenomena of radiation-pressure on attenuated gases.* Contrary conclusions were reached by previous authors mainly as a result of neglecting resonance pressure. AUTHOR.

1405. *The Response of the Average Pupil to various Intensities of Light.* **P. Reeves.** (Optical Soc. America, J. 4. pp. 35–43, March, 1920.)

1406. *Classification of Optical Glass.* **G. W. Morey.** (Optical Soc. of America, J. 4. pp. 205–212, July, 1920.)—The paper is an extract from the Report of the Sub-committee on Optical Glass Nomenclature, of the American Optical Society. The system of classification proposed is based on the crown-flint series of barium-free glasses. The criteria used are the value of n_D and of $\nu = (n_D - 1)/(n_F - n_C)$. Crowns with ν greater than 68 are termed fluor-crowns; borosilicate crowns have ν between 68 and 61, ordinary crowns have ν from 61 to 56. For extra light flints ν lies between 56 and 50, for light flints between 50 and 38, for medium flints between 38 and 34, and for dense flints between 34 and 31. Extra dense flints have a ν-value below 31. Barium crowns have n_D higher than 1·60, light barium crowns between 1·60 and 1·54. The barium flints are divided into light, with n_D less than 1·60; medium, between 1·60 and 1·64; and dense. It is emphasised that these names are for convenience in casual reference only, and do not imply a specification of optical properties. J. W. T. W.

1407. *Sine-Condition and Coma.* **E. Lihotzky.** (Akad. Wiss. Wien, Ber. 128. 2a. pp. 85–90, 1919.)—Discusses the application of the sine-condition as a criterion for absence of coma with central rays in the case of a lens system uncorrected for spherical aberration. J. W. T. W.

1408. *Dispersion in Optical Glasses.* **F. E. Wright.** (Optical Soc. of America, J. 4. pp. 195–204, July, 1920.)—The author, in a previous paper [see Abs. 1269 (1920)], has proposed certain linear relations between the partial dispersions of optical glasses. The present paper discusses the application of the Cauchy formula $n = A + B\lambda^{-2}$ or that proposed by Nutting, $1/(n - 1) = C + D\lambda^{-2}$, and shows that for crown glasses the Cauchy formula is the best, while for flint glasses neither formula holds with great accuracy. J. W. T. W.

1409. *A Photometer without Diffusing Screen.* **H. Buisson** and **C. Fabry.** (J. de Phys. et le Radium, 1. pp. 25–32, Jan.–July, 1920.)—It is usual in photometry to employ a white diffusing surface to receive the light of the source tested. This has two drawbacks: (*a*) the illumination from distant lamps may be unduly low; (*b*) it is difficult to discriminate the light from different sources, forming members of a group of lamps. The apparatus described avoids these difficulties by allowing light from the source tested to impinge on a lens, after which it passes though one surface of a Lummer-Brodhun cube to the eye. The other photometric surface in the Lummer-Brodhun cube receives light in a similar manner from a small comparison light, the photometric balance being effected by interposing a graduated absorbing wedge in the path of its rays. The displacement of this wedge is observed through a second telescope. The apparatus is calibrated by observation of a lamp of known candle-power in the usual way. The brightness of the field is much greater than would usually be the case with a white diffusing screen. J. S. D.

1410. *Brightness of the Unclouded Sky.* **M. Ulbe.** (Sächs. Akad. Wiss. Abhandl., Math. Phys. Klasse. 35. p. 219., 1918. Zeits Instrumentenk. 40. pp. 27–28, Jan., 1920.)—Describes a form of portable photometer designed for comparing the brightness of different parts of the sky. The two parts to be compared illuminate a photometer of the Lummer-Brodhun contrast type, and equality of brightness in the photometer is obtained by varying the thickness of a layer of liquid placed in the path of one of the beams of light. This liquid consists of an aniline neutral grey solution, but for light reductions of large ratio grey glasses are employed. The author has used the apparatus for determining the distribution of brightness of the clear sky as seen from a height of some 3000 m. in Teneriffe. J. W. T. W.

1411. *Optical Properties of Turbid Media.* **C. Chéneveau** and **R. Audubert.** (Ann. de Physique, 13. pp. 134–161, March–April, 1920.)—In the experiments described use has been made of emulsions of gutta-percha and mastic, fine precipitates of silver chloride and barium sulphate, emulsions of oil in water and of water in oil, and inclusions of liquid spherules in solid resins. Only the absorption and diffusion have been studied, the polarisation being negligible in amount. The results obtained show that the absorption of an emulsion, $1 - I/I_0$, is connected with the physical properties by the expression,

$$1 - I/I_0 = e^{-Ad^{\beta}/(Nd\cdot)^{\alpha}},$$

where I and I_0 represent the respective intensities of the incident and transmitted light of wave-length λ, N the number of particles of diameter d in unit of volume, and α, A, and β are coefficients, A varying with the wave-length and with the nature of the particle and β with the nature of the particle alone.

To large particles it is legitimate to apply the formula, $I/I_0 = e^{-A/\lambda^n}$, the exponential n being independent of the wave-length. From this is derived the equation,

$$1 - I/I_0 = e^{-KNd\lambda^n},$$

in which K is a coefficient depending solely on the optical properties of the granules and of the intergranular medium; this formula has the advantage that it brings out clearly the variation of the absorption for different rays.

The case of non-homogeneous turbid media is also considered and the general theory of the phenomena discussed. T. H. P.

1412. *Photographic Photometry and the Purkinje-Effect.* **F. E. Ross.** (Eastman Kodak Co.'s Research Lab., Comm. No. 95. Astrophys. J. 52. pp. 86–97, Sept., 1920.)—*Contrast properties of photographic plates.—The variation with wave-length of the contrast, or gamma, and of* the rate of increase of the diameters of stellar images with the exposure, which the author calls *astrogamma* (Γ), is shown for four emulsions by curves. These results, which lead to a photographic Purkinje-effect, are explained as due in part to *the variation in the penetration of light of different wave-lengths*, which the author determined from sections of images, and in part to variations in the number of silver grains sensitive to various colours. Other factors also enter.

Heterochromatic photographic photometry.—After discussing the criteria to be satisfied by an accurate photometric method, the author points out the *possibility of large error* unless γ is constant for the range of wave-lengths involved or unless filters specially adapted to the particular plates are used. From the curves given, it is evident that orthochromatic and panchromatic plates are more suitable for photometric purposes than ordinary blue-sensitive plates. In applying photographic photometry to astronomical problems, extreme circumspection is necessary to avoid erroneous conclusions. AUTHOR.

1413. *The Diffraction Theory of Microscopic Vision.* **P. N. Ghosh.** (Phys. Rev. 14. pp. 497–502, Dec., 1919.)—The changes that take place in the resultant diffraction pattern when a black crossed-grating on a white ground is viewed through a very long rectilinear slit, the axis of which is inclined at an angle of 45° to the lines of the grating and when the slit width is gradually decreased, are described, and reproductions of photographs of typical stages in the image distortion are given. It is shown that when the slit is sufficiently narrow the diffraction field consists of a series of equidistant bright and dark lines at right angles to the chief axis of the slit.

The elemental case of a single black 90° cross on a white ground, when viewed through a slit which is parallel to the bisector of a pair of vertical angles of the cross, is subjected to approximate mathematical analysis, and the contour lines are given both numerically and graphically. It is explained how a synthesis of the elemental pattern accounts, qualitatively at least, for the more general case. Author.

1414. *Image Contraction and Distortion on Photographic Plates.* **F. E. Ross.** (Eastman Kodak Co.'s Research Lab. Comm. No. 94. Astrophys. J. 52. pp. 98–109, Sept., 1920.)—*Contraction and distortion of photographic images during drying.*—When pyrometol or caustic hydroquinone are used, extended images contract by an amount depending on the developer, on the size and density of the image, and on the temperature. The contraction reaches a maximum for images 5 mm. or more in diameter. The increasing contraction with increasing density of image may be sufficient to overcome the normal increase of size with density so that the diam. of the image may actually decrease to a minimum as the exposure is increased. The effect is especially marked in hot weather. The phenomenon is probably a result of unequal drying of image and surrounding gelatine. Hydroquinone, metol-hydroquinone, and chlorhydroquinone seem to give images free from this contraction effect.

Astronomical measurements from photographs.—The possible errors due to the contraction effect may be large. Images of *double stars* may be too close together; star images near the solar corona may be attracted so as to lead to apparent deflections which must be corrected if the *Einstein effect* is to be determined.

Attraction of close lines on spectrograms.—This contraction effect depends on the developer and on the width and separation of the lines. Author.

1415. *Dyes for Photographic Sensitising.* **W. F. Meggers and F. J. Stimson.** (Optical Soc. of America, J. 4. pp. 91–104, May, 1920.)—Both the absolute and the spectral sensitivity of silver bromide are powerfully influenced by the action of so-called sensitisers, which have been generally grouped into two classes: (1) the chemical sensitisers, and (2) the optical sensitisers. There is no doubt that the principal factor in the action of all sensitisers is their great absorption of light. The absorption of light is regarded as being conditioned by resonance phenomena depending upon electromagnetic and other physical properties of the resonators. The ultra-microscope has shown that gelatine consists of a homogeneous mass containing aggregates which, in a gelatine silver-halide emulsion, would be naturally associated with the halide in forming the above-mentioned resonators; thus offering an explanation of the sensitising action of gelatine. An illustration is given of the photographic impression made by a continuous spectrum upon Seed's 23 plates before and after treatment with typical sensitising dyes. The plates were stained in dye-baths as described and then illuminated by light from an incandescent lamp. The violet and ultra-violet parts of the spectrum are not shown, since only waves longer than those of blue light are of great interest in connection with the sensitising dyes. It is often true that the unstable or fugitive dyes are the best sensitisers. This is especially true with the best sensitisers for red and infra-red, but it is not a general rule, inasmuch as some dyes which sensitise strongly are also quite stable. It is a general law that the spectral sensitivity imparted by a dye corresponds rather closely with the position and shape of bands in the absorption spectrum of the dye, but only a comparatively small number of dyes act as photo-sensitisers although they all have absorption bands. It appears that it is necessary for a dye actually to stain the silver salt to become a sensitiser, and the absorption band of the dyed silver salt seems to correspond exactly to the spectral band of sensitiveness imparted to the emulsion. This would be expected if resonance-absorption of energy and photoelectric effect are responsible for the sensitising action. The absorption spectra of some typical photosensitising dyes in alcoholic solution are given, as are also reproductions of photographs showing the effect of staining with pinacyanol and using an orange colour-filter. A. E. G.

1416. *Photo-Micrography in Photographic Research.* **G. I. Higson.** (Phot. J. 60. pp. 140–143; Disc., 143–145, April, 1920.)—The application of photo-micrography to photographic research offers some considerable difficulties, and in order to overcome these a special form of apparatus has been designed for this particular purpose. Since the highest possible magnification is almost invariably required, oil-immersion both for the objective and the substage condenser are necessary so as to keep the optical system homogeneous. It is for the rapid production of photomicrographs under these conditions that the present apparatus is designed. All arrangements necessitating the use of a camera are inadmissible, as these suffer from three grave defects; they are difficult to focus, it is very easy to jar the apparatus while introducing the dark slide into the camera and removing the dark-slide shutter, and it is impossible to know really whether a result has been successful until after the plate has been developed. The absence of a camera means that the light source, either with or without the microscope, must be shut off from the rest of the apparatus, and it is found that the most convenient method is to enclose the lamp. The "Pointolite" lamp is adopted for this purpose. There is no complicated optical bench system, all lenses being on the microscope stand itself. In place of the camera there is simply a large wooden block, 3 ft. by 3 in. by 8 in., resting on two semi-inflated air-cushions to protect the system from vibration. Owing to the apparatus being on the top of this block it is top heavy, and it is necessary to keep it from falling by means of a small air bulb, placed between the light-tight box and the wall at the rear. The light-tight box which is mounted on one end of the block contains the Pointolite lamp. This lamp is rigidly connected to the block by a series of jointed rods so that it can be clamped in a suitable position. On the side of this box is a tube containing a holder for a light-filter, and this tube makes connection with the substage condenser of the microscope when the latter is placed on the block in a horizontal position and aligned against suitable stops. At the far end of the block is placed a vertical easel with a white card upon which the enlarged image is projected. Beneath this card runs a narrow ledge and the plate rests upon the ledge during exposure. A shutter designed for exceptionally vibrationless work need not be employed, as the rest of the apparatus is isolated from the shutter by its air-cushions. The procedure is very simple. The optical system of the microscope, having been centred, this is placed in position on the block and the lamp is moved on its stand until the "pip" of the light is centred in the field. In this position the lamp is fixed and but rarely needs adjusting. In making exposures the whole room is darkened or illuminated only with a faint red light. The lamp having been started and the object placed on the stage and immersed in oil between the objective and the substage condenser, it is roughly focused on the screen, and the magnified image of the lamp "pip" is also brought into focus on the screen by adjustment of the condenser. Final adjustment of the objective and condenser, made just before exposure ensure that both of these images are accurately in focus when the photograph is taken. The shutter having been closed, a plate is then placed in position on the ledge of the easel. The focal plane is thus moved nearer to the microscope by a distance equal to the thickness of the plate, but no ill effects have been noticed from this. As backed plates are invariably used it is unnecessary to cover up the white focusing screen. The operator can, so to speak, actually see the exposure being made, *i.e.*, he can detect as soon as the exposure commences, any alteration in the focus which would spoil the result. A. E. G.

1417. *Optical Constants of Liquid Alloys.* **C. V. Kent.** (Phys. Rev. 14. pp. 459–489, Dec., 1919.)—This paper describes a determination of the two optical constants of molten metals, the index of refraction, ν, and the index of absorption, κ, from the reflection of polarised light at molten-metal surfaces, placed in an inactive atmosphere.

The *purpose* of this experiment is to throw some light upon the behaviour of free electrons in metals.

Method.—The constants, ν and κ, are computed from the phase change Δ, and the azimuth change ψ, of polarised light reflected from the surface of the liquid metal at an angle of incidence ϕ. A Jamin circle is employed, the azimuth of the analyser being determined by a bi-field of new design.

A furnace for melting the metals is made up by winding a few yards of nichrome wire on a hollow iron cone, thus maintaining a temperature of about 400° C. The whole furnace is operated in a water-cooled container through which a stream of hydrogen is made to flow continuously.

The metals employed are bismuth, cadmium, tin, lead, and binary alloys of these. As a source of light, three strong rays from a quartz mercury arc are used.

Results.—A good optical surface is obtained, free from the scratches and impurities of polishing materials.

Values of $\nu^2 - \kappa^2$ and $2\nu\kappa$, are plotted as functions of the composition (atomic concentration) of each alloy. The parameters of the free electrons are also computed and plotted as functions of the composition of the alloy. These parameters are: (1) the product Ne^2/m, where the symbols have the meanings usually given in the electron theory, and

(2) the frequency of impact of a free electron with the molecules of the metal.

From these optically determined free electron parameters, the electrical resistivities of the pure liquid metals and alloys are computed. In every case the agreement with the known electrical resistivity is within the limits of experimental error. A possible explanation of the disagreement between the values of resistivities for solid metals as computed from optical data and from direct electrical measurement is suggested.

The results seem to indicate that the simple free electron theory of Drude and others is applicable to molten metals. AUTHOR.

1418. *The Contrast Sensibility of the Eye.* **E. Karrer and E. P. T. Tyndall.** (Bureau of Standards, Bull. 15. pp. 679–692 [Sci. Papers No. 366], 1920).—The research formed part of an investigation of problems of searchlight illumination. The detection of objects illuminated by a searchlight beam is largely a matter of contrast. A screen was illuminated to a known value so that its brightness was comparable with that of the path of a searchlight beam. Upon this screen was projected a rectangular beam, of variable horizontal width. The observer thus saw a rectangular strip of light upon a light background, and the length of the strip was varied from nothing to a length which enabled an observer at a distance of 26·3 mm. just to see the patch. Two series of observations were made: (1) The field illumination and strip illumination were varied by steps in the same ratio, preserving constant contrast; (2) the field brightness was kept constant and the strip brightness varied by steps, thus giving a varying contrast. The nature of the apparatus and method of recording observations are described in detail and the results are assembled in diagrammatic form. Curves connecting ratio of brightness difference to field brightness and visual angle tend to become asymptotic with both coordinates. Under certain conditions a very small change in the size of the target demands a great change in contrast or field brightness. This relationship might possibly be adapted to the measurement of distance. Evidence of fatigue, in some cases leading to crossing of curves, occurs, and in order to obtain accurate results a large number of observers should be employed. J. S. D.

1419 *Polarisation of Radiation by Gratings.* **L. R. Ingersoll.** (Astrophys. J. 51. pp. 129–139, April, 1920.)—*Polarising effect of gratings.*—(1) *Reflected radiation.* After a brief review of previous investigations, both theoretical and experimental, the author points out that while the Rayleigh-Voigt theory predicts an anomalous effect for a wave-length equal to the grating space, no experimental investigation of polarisation effects for a range of wave-lengths which includes the grating space has been made. Accordingly the author *tested four speculum gratings,* whose grating space varied from 1·2 to 2·7 μ, with plane-polarised light of wave-length 0·5 to 2·3 μ, and obtained the reflecting power of the ruled surface relative to the polished unruled surface for normal incidence. With the polarisation (electric vector) perpendicular to the rulings, a sharp minimum was found at a wave-length equal to the grating space and also, in some cases, for approximately one-half and one-third this value. Observations made with an incidence of 7° gave two minima at wave-lengths equal to the grating space multiplied by $(1 \pm \sin \theta)$. As the curves show, the polarising action depends not only on the wave-length but also on the particular grating used; and since polishing the gratings resulted in practically no change the effect must depend upon the groove form. (2) *Transmitted radiation.* The author also *tested some collodion replica gratings* with spaces of either 1·0 or 1·6 μ. The transmitted light was found to be partially polarised at right angles to the rulings; also the polarising effect showed maxima for wave-lengths equal to the grating space and to half that value. (3) *Radiation diffracted tangentially* from the speculum gratings showed a marked polarisation at right angles to the rulings. (4) *Conclusions.* These experiments show that the excess of perpendicularly polarised energy present in light tangentially diffracted from a reflecting grating is accompanied by a deficiency in radiation of this polarisation in the directly reflected beam; thus they tend to confirm the Rayleigh-Voigt theory. AUTHOR.

1420. *Wave-lengths in Red and Infra-Red.* **C. C. Kiess** and **W. F. Meggers.** (Bureau of Standards, Bull. 16. pp. 51–73 [Sci. Papers No. 372], 1920.)—Continuing their systematic investigation of spectra in the red and infra-red regions [Abs. 1160 (1918)], the authors have made careful measurements of wave-lengths of lines in the spectra of titanium, vanadium, chromium, manganese, molybdenum, tungsten, and uranium. The concave-grating spectrograph of the Bureau of Standards was used to photograph the yellow, red, and infra-red arc spectra of these elements, the plates used being sensitised to the red and infra-red rays with pinacyanol and dicyanin. For many of the plates American-made dyes were used, and these were as effective in their sensitising power as others previously employed. More than 2600 wave-lengths were derived from the measurement of the plates, many of them being the wave-lengths of heads of bands which are prominent in the spectra of titanium, vanadium, and chromium. Impurity lines have been eliminated from the tables, so far as known, those not identified being brought together in a separate table. Lines whose wave-lengths agree with those in the series spectrum of oxygen have been observed in several spectra. Frequency differences which appear to be constant have been found in each of the spectra dealt with. A. W.

1421. *Extension of the Ultra-violet Spectrum.* **R. A. Millikan.** (Astrophys. J. 52. pp. 47–64, July, 1920.)—*Extreme ultra-violet spectra to* 202 Å.—Using high-potential sparks in a vacuum as sources of light and a high-vacuum spectrometer with specially ruled concave gratings, the author has succeeded in extending the spectra of carbon, zinc, iron, silver, and nickel to λλ360·5, 317·3, 271·6, 260, and 202, respectively. *Vacuum spark spectra with carbon, zinc, iron, and nickel electrodes* are shown in Plates I–III of the paper. In all of these spectra there are lines which extend much beyond the width of the spark and are presumably due to gases driven from the electrodes. One of them is probably the hydrogen line λ1215·7; but though most of the others are identical with the lines obtained by Lyman from his *condensed discharge in helium*, reasons are given for believing that these gas lines are associated with carbon rather than with helium.

Vacuum spark spectra of carbon from λ7000 *to* λ360.—The main lines above λ2000 were identified and those below λ2000 are given, accurate to within about 0·2 Å.

L series of the X-ray spectrum of carbon.—Evidence is presented for believing that the whole spectrum which the carbon atom is able to emit up to and including its X-radiations of the so-called L series has now been obtained. Previously no lines of the L series of any element with an atomic number less than 30 had been identified.

High-potential vacuum sparks are sources of X-rays, and appear to produce hydrogen. AUTHOR.

1422. *Excitation of the Spectrum of Helium.* **K. T. Compton** and **E. G. Lilly.** (Astrophys. J. 52. pp. 1–7, July, 1920.)—*Minimum voltage for excitation of the helium spectrum.*—The spectrum was excited by bombarding very pure He with electrons from a hot-filament kathode at various pressures up to 24 mm. The *singlet and doublet series and band spectrum* appeared simultaneously at 25·5 volts with low pressures and at voltages as low as 20 with higher pressures and current-densities. The corresponding figures for the *enhanced line* λ4686 are 80 and 55 volts. These results indicate that the minimum voltages for the excitation of a normal He atom by a single electronic impact are 25·5 and 80 volts; but when multiple impacts assist, the corresponding voltages may drop to 20 and 55, but no lower. This last value agrees with that predicted by the Bohr theory for the energy necessary to displace the second electron from a singly-ionised He atom. The fact that after striking the arc it could be maintained on as little as 8 volts by using high currents indicates that in an intense discharge a large proportion of the atoms are in an abnormal state and therefore require less energy for excitation.

Helium arc spectrum; relative intensity of series and bands.—As the voltage was increased, the sharp subordinate series became relatively weaker. As the pressure was increased, the band spectrum became stronger and the enhanced line weaker. The band spectrum was stronger near the kathode, while the enhanced line was stronger near the anode.

Spectrum of neon in helium.—A trace of neon in the helium arc caused the neon lines λ5331 and λ5431 to appear with remarkable intensity. AUTHORS.

1423. *Note on the Air Lines in Spark Spectra from* λ5927 *to* λ8719. **P. W. Merrill.** (Mt. Wilson Observat., Contrib. No. 183. Astrophys. J. 51. pp. 236–243, May, 1920.)—*Air lines in condensed spark spectra; λ5927 to λ8719.*—As an essential preliminary to the investigation of spark spectra in this region, a study of the air lines has been begun by comparing spectra obtained with different elements as electrodes, both in air and in oxygen. (1) The *wave-lengths* of 58 air lines, so determined, are given with an accuracy which is limited by the fact that the lines are usually ill-defined and sometimes broad and hazy. Twenty of them correspond to known H, N, O, or A lines, including six lines of the *red spectrum of argon* and four *oxygen lines* which had not previously been observed in spark spectra. Except for two more, which are probably due to oxygen, the rest have not, as yet, been identified. (2) All of the identified lines are found to be *shifted with reference to vacuum tube spectra*; the increase of wave-length is about 0·1 Å. for the *oxygen lines* and two *nitrogen lines*, 0·3 Å. for three other N lines, 0·6 Å. for the *argon lines*, and 0·7 Å. for *hydrogen alpha* and for three other N lines. (3) The *effect of adding self-inductance* is to weaken the two *nitrogen lines*, λλ6482 and 6610.

Spectrum of condensed spark in oxygen.—Several identifications of oxygen and nitrogen lines by previous observers using vacuum tubes are confirmed and the doubtful identification of λ7157 as due to oxygen is strengthened. AUTHOR.

1424. *Absorption in Spectral Lines from the Standpoint of the Quantum Theory.* **C. Füchtbauer.** (Phys. Zeits. 21. pp. 322–324, June 15, 1920.)—Measurements of several cæsium lines have previously been given [Abs. 229 (1914)]. Absorption curves were obtained which gave information as to the form of the broadened lines. The present paper discusses these results from the standpoint of the quantum theory. A certain "probability factor," closely related to the intensity of spectral lines, is defined, and its value calculated for the different lines considered. A. W.

1425. *Fine Structure of the Near Infra-red Absorption Bands of the Halogen Acids.* **W. F. Colby.** (Astrophys. J. 51. pp. 230–235, May, 1920.)—*Absorption spectra of diatomic gases; a quantum theory of the fine structure of the infra-red bands.*—The postulate of Bjerrum, that the fine structure of these bands is due to the rotation of the molecules in stationary states corresponding to the quantum relation, has proved very fruitful. The purpose of the present paper is to test the hypothesis by comparing the *theoretical results for the simplest molecular model of the Bohr type* with the experimental results recently obtained by Imes for the *halogen acids.* For HF, HCl, and HBr, the observed interatomic vibration frequencies come out respectively 18, 40, and 47 % less than the theoretical, while the computed separations of the pairs of nuclei are respectively 38, 54, and 59 % less than the values given by Imes. The variation with mass is explained as a screening effect which has been neglected in the elementary theory. The agreement between theory and experiment is sufficient to lend support to the Bjerrum hypothesis, and suggests the importance of developing a more adequate theory involving fewer simplifying assumptions. AUTHOR.

1426. *Wave-length Measurements in the M series of some High-frequency Spectra.* **J. C. Karcher.** (Phys. Rev. 15. pp. 285–288, April, 1920.)—*New vacuum X-ray spectrograph.*—The paper contains a description of an X-ray spectrograph designed to be used in the same chamber containing the source of X-rays, also a description of the *vacuum chamber*, the *method of sealing*, and *details of manipulation* of the apparatus.

A method is described of determining the position of the photographic plate upon which the lines are photographed.

Experimental data.—Some measurements are made of lines in *the M series of bismuth, lead, thallium, mercury, gold, and platinum.* AUTHOR.

1427. *Colouring and Thermoluminescence of Glass produced by Radium Radiation.* **S. C. Lind.** (J. Phys. Chem. 24. pp. 437–443, June, 1920.)—Several different explanations of the colouring of glass and of transparent minerals by radiation have been proposed, none of which appears to be entirely satisfactory. The object of the present notes is, not to attempt to decide between the different theories nor to propose a new one, but rather to assist in keeping the records straight by pointing out some of the errors of observation or generalisation that are becoming rather commonly accepted, and by showing that the phenomena are perhaps more complicated than has been usually assumed. A brief summary of the phenomena is given under the following heads: Colouring by radium radiation; Discharge of colour (*a*) by heat, (*b*) by radiation; Change of colour; Thermoluminescence not accompanying change in colour; Thermoluminescence accompanied by change of colour; Mechanical effects of radiation on glass and quartz. It is concluded as the result of experiments carried out that there are great difficulties in the way of finding a theory to explain all the phenomena observed. Any attempt to attribute difference in colour to small quantities of impurities encounters an almost, if not wholly insurmountable difficulty if it is admitted that the same piece of glass can take two different colours by merely changing the strength of the radiation. Attention is called to the erroneous impression that seems to be accepted in the literature that the thermoluminescence of glass and the discharge of colour by heat are simultaneous phenomena, probably having a common cause. While this may be true for the change brown → violet, in the case of violet-coloured glass or silica the two phenomena occur at temperatures differing at least by 300 deg. C. from each other. The thermoluminesce can be wholly exhausted without diminishing the violet colour in the least. So it appears that radiation produces at least two different reactions (or conditions) in glass, the reversal of which at two entirely different temperatures leads, the one to luminescence, the other to discharge of colour. If thermoluminescence is due to chemical action, the fact that it takes place at quite low temperatures (60°) with fair rapidity suggests that the same reaction may be proceeding at ordinary temperatures, but so slowly that no luminescence is visible. This view is supported by the observation of the diminished ability of old radiated glass to slow thermoluminescence. Meyer and Przibram found a rather pronounced photoelectric effect for radiated kunzite and fluorspar, and to a less degree for glass. This observation naturally leads to a physical theory of the colouring by a displacement of electrons. This theory has not been more fully developed. Newberry and Lupton have subjected a large variety of substances, including glass and minerals, to Becquerel rays. They ascribe the effects to "the association of minute traces of certain impurities."

A. E. G.

1428. *Soft X-rays: Note on an Article by H. M. Dadourian.* **E. R. Laird.** (Phys. Rev. 15. pp. 293–296, April, 1920.)—*Soft X-rays:* (1) *Criticism of use of electrostatic trap to avoid methodical errors of observation.*—Unless the field is fully symmetrical, one kind of ions or of rays will get through, and light is not thus trapped.

(2) *Criticism of measurements of photo-electron velocities.*—The beforementioned sources of error are present, and the use of a secondary field renders uncertain the value of the supposed retarding field.

(3) *Criticism of the values given for variation of intensity of radiation with voltage, and for absorption in celloidin films.*—Errors as in (1) persist. Experiments are described exhibiting similar variations the incorrectness of which is shown by a comparison of the photoelectric and ionisation currents, and by observations with the apparatus further denuded of gas. A *discussion* is given of the use of the term soft X-rays, and the *suggestion* is made that the intensity of radiation in this region from a solid, produced by the impact of kathode rays of less than 200 volts velocity, is small. AUTHOR.

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1429. *Connection between Optical and Röntgen Spectra.* **E. Gehrcke.** (Phys. Zeits. 21. pp. 378–381, July 15, 1920.)—Starting with a model atom differing from Bohr's hydrogen atom by a factor 2, so that the positive nucleus and the electron paths have twice the radius given to them by Bohr, the Balmer series can be deduced [Abs. 1056 (1914)]. In the present paper Sommerfeld's formula for the fine structure of spectral lines is first deduced, then Moseley's formula for the K Röntgen spectra is obtained. This is followed by Sommerfeld's formula for the fine structure of Röntgen spectra. A. W.

1430. *Quantum Emission Phenomena in Radiation.* **D. L. Webster.** (Phys. Rev. 16. pp. 31–40, July, 1920.)—*Comparison of X-rays and light: a summary.*—This covers the best-known cases of excitation of line spectra by electron impact, and *the form of the Bohr theory,* that is required by them.

Comparison of emission and absorption.—The above phenomena are compared with corresponding absorption phenomena, with especial reference to the accumulation of energy for photo-electrons by absorption.

Deductions.—Theories of the type of *Bohr's* appear *inconsistent with these facts.* The phenomena suggest that the law of the *conservation of energy,* as applied to atomic oscillators, *holds only statistically. A set of postulates to replace it* for individual oscillators is outlined. AUTHOR.

1431. *Soft X-rays produced by Kathode Rays of from* 200 *to* 600 *Volts Velocities.* **E. R. Laird** and **V. P. Barton.** (Phys. Rev. 15. pp. 297–308, April, 1920.)—*Soft X-rays; examination of method of investigation using no window.*—Previous results by one of the authors are briefly referred to, and a new experiment is described showing the difficulties in measuring a photoelectric effect due to soft X-rays produced in the same chamber as that which contains the photoelectric electrode.

Soft X-rays produced by kathode rays of between 200 *and* 600 *volts velocity; effect of occluded gases in the antikathode on the intensity.*—The *method* used for estimating the radiation produced was to allow the soft X-rays to ionise the gas in a chamber separated from the discharge tube by a thin celluloid window. (*a*) A platinum antikathode was partially denuded of gas by glowing, and (*b*) the remnants of gas in the tube were displaced by hydrogen: the intensity of radiation was not notably altered. The *conclusion* is drawn that the radiation observed comes from the solid antikathode.

Variation of intensity of radiation with voltage for antikathodes of brass, platinum, graphite, aluminum, lithium, and for gas remnants, air, hydrogen, and carbon disulphide.—After showing that the radiation is proportional to the kathode-ray current, and that relative measurements could be fairly well repeated, even with different *pressures of gas in the ionisation chamber,* the authors give details of the relative intensities and of the actual ionisation current at 600 volts. The intensity at 300 volts was less than 2 per cent. of that at 600 volts.

Characteristic and general X-radiation.—From a comparison of (*a*) the radiation from different antikathodes, and (*b*) the intensity as measured by ionisation and by the photoelectric effect, it is inferred that the radiation is largely general. There is evidence of a characteristic (K) radiation from carbon, and one observation suggesting a characteristic (L) radiation from aluminium. At the end of the paper are found *sug-*

gestions of possible reasons for the similarity of behaviour of different antikathodes.

Soft X-rays from 200 *to* 300 *volts.*—It appears that the radiation in this region ionises the gases used relatively less powerfully in proportion to its photoelectric effect.

X-radiation below 190 *volts.*—Tests are described showing that the effects thus far obtained by the authors were due to gas in the tube and not to a radiation from the solid antikathode. AUTHOR.

RADIO-ACTIVITY.

1432. *Ratio of UrY and UrX.* **A. Piccard** and **E. Stahel.** (Archives des Sciences, 2. pp. 263–265, May–June, 1920. Paper read before the Soc. Suisse d. Physique.)—Describes a re-determination of this ratio. A value of approximately 8 %, or more roughly 1/12, is now given as trustworthy. A. B. W.

1433. *Experimental Answer to the Question of Radio-activity of all the Elements.* **G. Hoffmann.** (Ann. d. Physik, 62. 8. pp. 738–758, Aug. 20, 1920.)—As a result of a series of measurements of the magnitudes of the ionisation effects produced by a single α-particle from different radioactive substances, the author shows the improbability of substances like copper, for instance, possessing characteristics of radio-active substances. A. B. W.

1434. *Scattering of γ-rays.* **K. W. F. Kohlrausch.** (Phys. Zeits. 21. pp. 193–198, April 15, 1920.)—A description is given of a series of measurements of the scattering of γ-rays from RaC (from 807 mgm. $RaCl_2$) through different angles. Cardboard, aluminium, zinc, tin, and lead were used as the scattering materials. A. B. W.

1435. *Radio-activity of Spring Waters.* **O. Nürnberger.** (Phys. Zeits. 21. pp. 198–203, April 15, 1920.)—Measurements have been made by different apparatus and methods of the radio-activity of various samples of spring water. The results obtained are in good agreement with those previously made by Duane, but differ from observations made by Schmidt, Berndt, and Götz. Wide variations from the normal radio-active content of the spring water have been shown to be due to the Lenard-effect and to "temperature currents." A. B. W.

1436. *Application of the "Displacement Law" to Substances emitting α- and β-rays simultaneously.* **O. Hahn** and **L. Meitner.** (Zeits. f. Physik, 2. 1. pp. 60–70, 1920.)—The chemical nature of the successive radio-active decay products is known through what is known as the "displacement law." If a radio-active substance emits α-particles, the nuclear charge and consequently the atomic number of the resultant product is reduced to two units less than that of the parent substance, *i.e.*, the resultant product is displaced two places to the left in the groups of the periodic system of elements. If β-particles are emitted, then the nuclear charge is in effect increased by one unit, and as a consequence the resultant product is displaced one place to the right in the groups of the periodic system.

The relation is somewhat complicated, however, when the substance under consideration emits α- and β-particles simultaneously. The first case arises where a fraction of the atoms of the parent substance emits α-particles whilst the remainder emits β-particles—two distinct products resulting from such a transformation. In this case the two resulting products conform to the ordinary displacement law outlined above. As examples of this may be cited the "C" products of all radio-active series, thus:

$$\begin{tikzcd}
 & \mathrm{Ra^6C'} \arrow[dr, "\alpha"] & \\
\mathrm{Ra^5C} \arrow[ur, "\beta"] \arrow[dr, "\alpha"'] & & \mathrm{Ra^4D,} \\
 & \mathrm{Ra^3C''} \arrow[ur, dashed] &
\end{tikzcd}$$

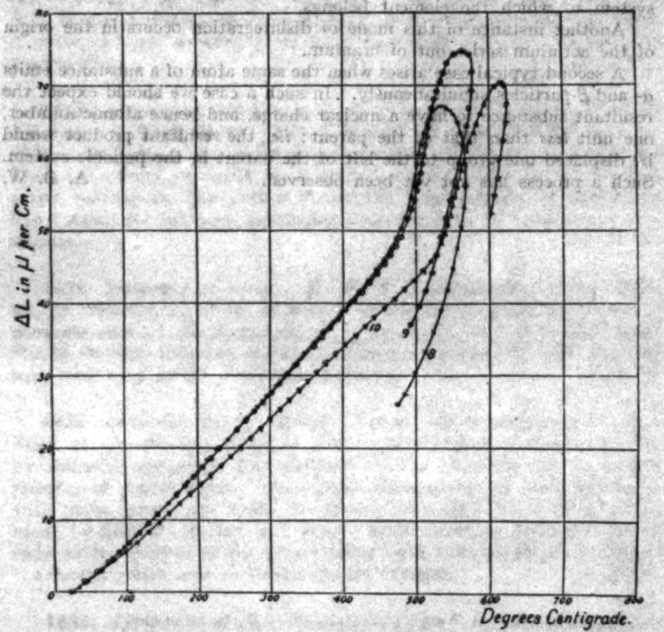
the numeral over the chemical symbol indicating the group in the periodic system to which the element belongs.

Another instance of this mode of disintegration occurs in the origin of the actinium series out of uranium.

A second typical case arises when the same atom of a substance emits α- and β-particles simultaneously. In such a case we should expect the resultant substance to have a nuclear charge, and hence atomic number, one unit *less* than that of the parent; *i.e.*, the resultant product would be displaced one group to the left of the parent in the periodic system. Such a process has not yet been observed. A. B. W.

HEAT.

1437. ***Thermal Expansion of Glass at High Temperatures.*** **C. G. Peters and C. H. Cragoe.** (Optical Soc. of America, J. 4. pp. 105–144, May, 1920.)—After a summary of previous work on this subject [see Abs. 1260 (1918)], the authors describe in full the interferometer method adopted for measuring the thermal expansion (linear) of specimens of glass. The apparatus consisted essentially of a section of glass rod or tube, about 1 cm. thick, separating two quartz plates and enclosed in a furnace, the temperature being measured by means of thermo-couples, and the expansion by the shift of interference bands between the quartz plates when under illumination by yellow light from a helium source. The observations were corrected for the variation with temperature of the refractive index of air. The expansion coefficients of thirty-two specimens of glass were found between 20° C. and a point above the softening temperature. In a table are given the mean coefficients over the range of regular expansion, *i.e.*, as far as 330° to 500° C. according to the particular kind of glass. The same table also gives the critical temperature region for each glass, and the much larger coefficient of



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expansion which holds in this region. At temperatures above this critical region it was found that contraction took place in every case. The chemical composition of the glasses is given. The results of the measurements are exhibited graphically in curves grouped according to the nature of the glasses. The curves for some of the optical glasses are shown in the Fig. It is seen that below the critical range glass has a regular expansion and contraction, retains its dimension when held at a given temperature for a long period, and returns to its original length on being carried through a temperature cycle; it may thus be considered as a solid. Upon passing through the critical region, *i.e.*, above the first bend in the curves, it seems to soften, or become viscous. When held at a constant temperature in the critical region, there is first an expansion, then a slow contraction. When held constant at points above the critical region, the rate of contraction increases with the temperature. The highest part of the curves, called the softening region, gives the temperature at which the contraction due to the softening is just sufficient to overcome the expansion due to the heating. At higher temperatures the contraction predominates, as indicated by the rapid drop in the curve. It was found by subsidiary experiments that the observed contraction could not be due to settling of the glass specimen when softening commenced, and no appreciable volume contraction could be found. It was therefore concluded that the longitudinal contraction observed was due to spheroiding of the sample by surface tension. A comparison of results shows that the heat absorption observed by Tool and Valasek [Bureau of Standards, Sci. Papers No. 358] occurs in the same temperature region as the critical change in the expansion. It seems to be probable that most of the strains that exist in a piece of glass are introduced when it cools through the critical region. When cooled rapidly the outer shell reaches the critical temperature first and hardens, while the inner part still contracts at the rapid rate, which puts the outer shell under a high tension. When the sample is reheated, the outer shell softens first, and the tension of the inner part causes a contraction. It seems, therefore, that most of the strain introduced depends upon the magnitude of difference in the expansion coefficients above and below the critical region and the rate of cooling, and this point should be carefully considered when annealing a particular specimen of glass. For thorough annealing the glass should be held for a long time at a temperature near the middle of the critical region. For more rapid annealing the sample can be held above the critical region, then cooled very slowly through that region and more rapidly the remainder of the way. J. W. T. W.

1438. *Bromwich's Method of Solving Problems in the Conduction of Heat.* **H. S. Carslaw.** (Phil. Mag. 39. pp. 603–611, May, 1920.)—In a recent paper [Abs. 677 (1919)] Bromwich advocates the use of so-called operational methods, following Heaviside, in electrical and other physical problems, and illustrates his method by the solution of various problems, including some in the conduction of heat. The object of the present paper is to illustrate by some problems in linear flow the method which Bromwich's work has led the author to adopt in the discussion of a large class of problems in the conduction of heat. The author considers it easier to build up the required solution by integrating a suitable solution over a certain standard path in the plane of the complex variable. The proper particular solution will be easily obtained after a little practice in the method. Simple cases are first taken, and then a solution is obtained for the first time for the case of a rod composed of two different materials, the ends being kept at zero and temperature x_0 respectively, the initial temperature being zero. A. W.

1439. *Specific Heat of Saturated Vapour and the Entropy–Temperature Diagrams of Certain Fluids.* **J. A. Ewing.** (Phil. Mag. 39. pp. 633–646, June, 1920.)—By the expression specific heat of a saturated vapour (K_s) is meant the quantity of heat required, per unit of mass, to increase the temperature by one degree, while the pressure and volume are so altered that a state of saturation is maintained. When, as in steam, K_s is negative, the vapour becomes supersaturated or partially condensed when it suffers adiabatic expansion, and superheated when it undergoes adiabatic compression. Denoting the entropy of the saturated vapour by ϕ_s, it is shown that $K_s = T d\phi_s/dT$, so that K_s is negative under all conditions which make the entropy of the vapour increase as the temperature falls. In other words, K_s is negative so long as the entropy–temperature line for saturated vapour slopes downwards to the right, this being the normal form of the curve such as is found for steam, carbon dioxide, or ammonia. To make K_s positive would require that part of the line for saturated vapour should slope the other way. However strongly positive K_s may be at an intermediate temperature, it becomes, however, negative for all substances as the critical point is approached, for the saturation line must then bend over to the left to become continuous with the liquid line forming the other limb of the diagram; at the critical point the value of K_s is $-\infty$. Entropy–temperature diagrams are given for ethyl alcohol, propyl alcohol, ethyl ether, benzene, ethyl propionate and acetic acid. T. H. P.

1440. *Specific Heat of Saturated Vapours and Entropy–Temperature Diagrams of Fluids.* **A. W. Porter.** (Phil. Mag. 40. pp. 211–212, Aug., 1920.)—This paper is a comment on a recent communication by Ewing on the specific heats of saturated vapours [see preceding Abs.]. Reference is made to Duhem's work, where it is shown that if the specific heat of the saturated vapour is plotted against temperature, the form of the curve is that of an inverted, unsymmetrical U, which sometimes lies wholly in the negative region, but may lie higher up so as to cross into the positive region, and that if it does this it crosses twice. These are the two possibilities of which Ewing gives detailed examples. He asserts, however, that positive values do not occur for sulphurous acid, which statement appears to be erroneous. Owing to the importance of this substance in mechanical refrigeration, the author quotes the results of Mathias. The temperatures of inversion are 97·5° and 114° C. The author points out that the entropy of the liquid is not $\int[t, 0]C_p dT/T$, where C_p is the specific heat at constant pressure, even with the proviso that the value of C_p taken must be that at saturation, but that C_p must be replaced by K_w, the specific heat of saturated liquid. The difference between C_p and K_w is certainly negligible at temperatures sufficiently remote from the critical temperature, but it tends towards + infinity as the critical temperature is approached. The relation between the two quantities is: $K_w = C_p - T(\partial v/\partial T)_p \cdot dp/dT$. The values of K_w obtained by Mathias for SO_2 are given, and the author adds the increase

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per degree to show that K_w for SO_2 is not a linear function of the temperature even in a region remote from the critical region.

H. H. Ho.

1441. *Partial Condensation of Natural Gas at Liquid-Air Temperatures and a Curious Effect observed with the Nitrogen which dissolves in the Condensate.* **J. Satterly.** (Roy. Soc. Canada, Trans. 13. Sect. 3. pp. 109–121, 1919.)—When so-called natural gas, consisting largely of methane, other hydrocarbons, nitrogen, and sometimes helium, is passed into a tube immersed in liquid air, the hydrocarbons condense. If the condensate is withdrawn from the influence of the liquid air and allowed to warm, the pressure in the containing vessel increases to a certain point and then suddenly diminishes considerably. Possibly after the vapour-pressures of the methane and nitrogen have increased owing to the rise of temperature, some of the nitrogen is suddenly forced into solution and thus leaves the space above. The condensate is sometimes solid when the condenser is immersed in the liquid air, and in many cases the sudden diminution of pressure occurs at the instant the solid melts.

T. H. P.

1442. *Latent Heats of Vaporisation of Methane and Ethane.* **J. Satterly** and **J. Patterson.** (Roy. Soc. Canada, Trans. 13. Sect. 3. pp. 123–127, 1919.)—Two methods were employed in these measurements. In the first an electrically heated wire served to evaporate some of the liquid and in the second a piece of copper was lowered into the liquid. In both cases the liquid was at the boiling-point and the evaporated hydrocarbon was collected over water and its mass estimated from its volume. The amounts of heat supplied were determined from the wattage applied in the first case and from the mass and specific heat of the copper in the second. The mean values obtained, which are correct to within about 5 %, are: for the latent heat of vaporisation of methane, 138 cals. per gm., and for that of ethane, 260 cals. per gm.

T. H. P.

1443. *Variation of the Heat of Evaporation of Water with Temperature.* **H. v. Steinwehr.** (Zeits. f. Physik, 1. 4. pp. 333–336, 1920.)—The author deduces thermodynamically a formula for the latent heat of steam involving the difference of the specific heats of the vapour and the liquid, its temperature coefficient, and a constant. He starts from $r/T = \sigma$ ($r =$ heat of evaporation per gm., $\sigma =$ difference between the entropies of steam and liquid) and from Clausius: $dr/dT - r/T = -\sum S$. The formula is compared with Henning's experimental values (1909) for the interval 30 to 180°, according to whom the r decreases from 579 at 30·12° to 481·99 at 180·72°; the agreement found is good, within ± 2 units. Below 30° the agreement is less satisfactory.

H. B.

1444. *Spontaneous Inflammation of Ethyl Ether–Air Mixtures.* **E. Alllaire.** (Comptes Rendus, 168. pp. 729–730, April 7, 1919.)—Liquid ether is evaporated in a tube surrounded by a wire coil and then sent into a U-tube, the one limb of which is set with a series of points. When the ether portion was about 1 gm. per litre of air, spontaneous inflammation took place at about 190° C., in wide tubes probably at lower temperature, with absence of any catalysts such as the oxides of nickel, iron, copper, etc. Near the bluish flame the temperature rose to 460° C. There was no indication of chemical reaction before the inflammation. H. B.

1445. *Ignition of Mixtures of Air with Ether, Alcohol, Acetone in Contact with Heated Surfaces.* **A. G. White** and **T. W. Price.** (Chem. Soc., J. Trans. 116. pp. 1462–1505, Dec., 1919.)—A large number of fires having occurred in 1917 and 1918 in solvent-recovery stoves when cordite was being dried, especially with ether and alcohol, the authors investigated the matter in the Ardeer Factory, Stevenson, with particular regard to the ignition and the "sub-ignition temperature" of the vapours by contact with hot surfaces. The vapours were passed into evacuated tubes mostly of glass, electrically heated in a furnace; the catalytic surface influence was further studied by varying the dimensions of the tubes. The vapour entered the tube through a three-way cock and a "lead" of glass tubing. While a lead of 1 mm. diam. gave sub-ignition at 200° C., a lead of 5 mm. caused it at 60° or 50°; with a cock of 15-mm. bore and a lead of 19 mm., 80 cm. long, ignition was instantaneous on suddenly opening the cock (by hand) at 16·5°. This "shock-ignition" was investigated by varying the dimensions of the lead and tube and the vapour concentration, pressure, velocity, and temperature; the possibility of electric friction is not discussed. With tubes, 2·5 to 5·5 cm. wide, 100 cm. or more in length, the ignition always started well within the furnace. The sub-ignition temperatures found agree with the ignition temperatures previously published by the authors for alcohol and acetone; those for ether agree with Alilaire [see preceding Abstract], but differ from other figures available. Ether–air mixtures ignite at 187°, especially for concentrations ranging from 5 to 9 %. As the ether percentage rose from 1 to 2 %, the ignition temperature dropped from 480° to 200° and lower. Alcohol ignited at 500° and less, in the presence of ether already at 255° and less. Acetone–air mixtures also ignited about 500°. The presence in the solvents of glyceryltrinitrate scarcely affected these temperatures, but the presence of any peroxide (diethyl or hydrogen) made the vapours very dangerous. The explosions became much fiercer in glass tubes lined with metal, but such tubes corroded rapidly. The McDavid soap-bubble ignition method was found unreliable. It is mentioned (without particulars) that ether–alcohol–air mixtures could not be ignited by sparking from steel to steel, emery to steel, pyrites to steel, but readily by sparks from ferrocerium to steel. H. B.

1446. *Molecular Theory of the Vapour-Pressure of Solids and Chemical Constants.* **O. Stern.** (Zeits. Elektrochem. 25. pp. 66–80, March 1, 1919.)—A critical summary, starting from the Clausius-Clapeyron equation for the change of vapour-pressure with temperature. When the equation is integrated, the "chemical constant C" of Nernst comes in, which cannot be deduced from thermodynamical considerations. To arrive at a formula for C, the author, referring to Tetrode, Sackur, and others, presumes: that the attractive forces between the atoms may be neglected in the gaseous phase; in the solid phase the atoms do attract one another, the forces being in equilibrium about the centre of gravity of the atoms; and in crystals there is some orderly arrangement in the space-lattice, as to which he makes no special assumption,

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however. When an atom is moved from its equilibrium position, an opposing force proportional to the displacement is set up; the work to be done in this displacement is $N\varphi_0 = \lambda_0$, where λ_0 is the heat of sublimation at absolute zero. The deductions are made first on the assumption that all the atoms have the same mean frequency, and then for different frequencies. The formula arrived at for a monatomic gas is $C = \log(2\pi m)^{3/2}k^{5/2}/h^3$, where h and k are the Planck and Boltzmann constants. Exemplifications are not given. H. B.

1447. *Equation of State.* **M. P. Applebey** and **D. L. Chapman.** (Phil. Mag. 40. pp. 197–200, Aug., 1920.)—It has long been known that Clerk Maxwell's law of the equipartition of energy between the degrees of freedom cannot hold for the molecules of gases. The specific heats of solids at low temperatures prove that the translational kinetic energy of the atoms is not subject to the law, and even the energy of free translation of the atoms of helium has been shown to fall below the theoretical value 3/2R at high pressures and low temperatures [see Abs. 514 (1917)]. The assumption is therefore no longer justified that the mean kinetic energy of translation of a molecule is proportional to the temperature. Apparently the dynamical definition of temperature must be abandoned. While van der Waals' equation of state does not accurately represent the behaviour of gases, this was scarcely to be expected, since, in its deduction, the volume occupied by the molecules was assumed to be small in comparison with the volume of the gas, and the quantities "a" and "b" were taken as constant, whereas it is probable that these magnitudes vary with the temperature and density of the gas. The present authors now urge that fewer objections can be raised against van der Waals' equation than might be laid against other equations of state which are in much closer accord with the facts.

Van der Waals, in deriving his equation, assumed that the mean kinetic energy of a molecule was proportional to the temperature, whereas the justifiable conclusion is: $(p + a/v^2)(v - b) = \frac{1}{3}nm\bar{V}^2$; *i.e.*, the equation relates the pressure and volume of the gas with the total kinetic energy of translation of the molecules, but not with the temperature. To find a relation between pressure, volume, and thermodynamic temperature of a gas, the authors assume that in a closed space which contains a large number of like molecules the ratio of the number of molecules per unit volume whose potential energy is A to the number of molecules per unit volume whose potential is zero is given by the expression $\varepsilon^{-A/kt}$, k being the gas constant for a single molecule, and t the thermodynamic temperature. The distinction between this assumption and the corresponding proposition deduced from Maxwell's laws of the partition and distribution of energy, is that t is substituted in the assumption for $\frac{2}{3}$ of the mean kinetic energy of translation in the corresponding proposition. A modified form of van der Waals' equation is then deduced, namely: $kt[(Pb'/kt)/(e^{Pb'/kt} - 1)] + Pb'/2 = 2/3 \cdot m\bar{V}^2/2$, where P is the total internal pressure and b' the volume of fluid displaced by a molecule. The left-hand side with $h\nu$ substituted for Pb' is Planck's modified expression for the mean energy of a resonator of period ν. The distinction drawn between thermodynamic temperature and the kinetic energy of a degree of freedom is regarded by the authors as a provisional hypothesis which requires further examination. H. H. Ho.

1448. *Radiation from a Cylindrical Wall.* **A. C. Bartlett.** (Phil. Mag. 40. pp. 111–112, July, 1920.)—Obtains an expression for the amount of heat radiated from the inner walls of a vertical cylinder on to a horizontal coaxial disc, using Sumpner's theorem of the radiating sphere [see Abs. No. 733 (1920)]. J. W. T. W.

1449. *Stefan–Boltzmann Constant.* **M[arya] Kahanowicz.** (Accad. Lincei, Atti, 28. pp. 73–78, Jan. 5, 1920.)—In continuation of previous work [see Abs. 288 (1918)] the author describes a new determination of the constant σ in the Stefan–Boltzmann law. Determinations were made at various temperatures between 256° and 1075° C., and the constant was found to show no systematic variation over this range. The mean value obtained, with an Amerio receiver at two different distances from the radiator, was 5·61. J. W. T. W.

1450. *Surface Condensation Error in Certain Measurements of Vapour-Pressure by the Gas Current Saturation Method.* **A. W. C. Menzies.** (Am. Chem. Soc., J. 42. pp. 978–985, May, 1920.)—Investigation of the condensation of water from its saturated vapour in air on a steamed and water-washed glass surface, and on an acid-washed, steamed and water-washed asbestos surface under the conditions often prevailing in the use of the gas-current saturation method of vapour-pressure measurement, shows that the amount of this condensation is sufficient to account largely for unexplained irregularities recorded in the literature of measurements by this method. T. H. P.

1451. *Stefan-Boltzmann Constant.* **W. Gerlach.** (Zeits. f. Physik, 2. 1. pp. 76–82, 1920.)—A discussion of the most recent determinations of this constant. It is concluded that the value obtained by Kahanowicz [Abs. 288 (1918)] is too low owing to neglect of the absorption by the water-vapour and CO_2 in the air. The values found by Coblentz and Emerson and by the author are also too low on account of reflection losses from the blackened absorbing surface. The most probable value of the constant is considered to be $(5{\cdot}76 \pm 0{\cdot}07) \times 10^{-12}$ watt. cm.$^{-2}$ degree^{-4}. J. W. T. W.

1452. *A Principle of Duality in Thermodynamics.* **A. C. Lunn.** (Phys. Rev. 15. pp. 269–276, April, 1920.)—*Statement of the principle and comparison with dualities already known.*—It is shown that the general relations in thermodynamics can be arranged so as to exhibit a duality such that energy is dual to entropy and temperature to its reciprocal, leading to a systematic scheme of transformation of variables which may have value similar to the analogous principles already recognised in geometry, mechanics, and electromagnetic theory. It is pointed out that each physical concept has thus two corresponding modes of analytical representation and the same analytical form two physical interpretations.

Applications.—The working of the principle is illustrated by the interrelations of physical coefficients belonging to a fluid, and an example of symmetry of notation for entropy and energy equations and other pairs of formulæ by the transformation of thermodynamic potentials; and by the dualistic relation of the two Gibbs criteria of equilibrium and stability. AUTHOR.

SOUND.

1453. *Vibrations of Stiff Strings.* **O. Schaefer.** (Ann. d. Physik, 62. 2. pp. 156–164, May 28, 1920.)—Gives the theory of the vibrations of a string in which the effects of stretching force and stiffness are both appreciable. The result of the theory is then applied to a steel piano string 40 cm. long and 1 mm. diameter tuned to 435 per sec. In this case, because of the stiffness, the stretching force must be 75·83 kg., instead of 75·9 kg. as required for a perfectly flexible string. Further, the overtones of this stiff string will have the frequencies 870·9, 1309·5, 1750·8; instead of simply 870, 1305, 1740, as the frequencies would be if the string were quite flexible. E. H. B

1454. *Vibrations of Air in Conical Horns.* **A. G. Webster.** (Nat. Acad. Sci., Proc. 6. pp. 316–320, June, 1920.)—The horns dealt with are composed of a conical mouth and a cylindrical part, the far end of the cylinder being closed, the conical mouth open. The paper gives seven experimentally-obtained graphs for the pressures in the stationary waves inside these horns when a constant sound of pitch 256 vibrations per sec. was made outside it. Formulæ are also given for the conical and cylindrical parts and are in approximate agreement with the experimental results. E. H. B.

1455. *Experiments in Binaural Phase-difference Effect with Pure Tones.* **M. Simpson.** (Phys. Rev. 15. pp. 421–424, May, 1920.)—There are no published results which show the variation of angular displacement of the apparent source of sound with changes in phase-difference at the ears.

Linear relation between angular displacement and phase-difference.—Tuning-forks were used for the source of pure tones. Equal intensity was maintained at the two ears, while a difference in phase was secured by a difference in the lengths of the sound paths to the two ears. Results were obtained which are best represented by a linear relation between the phase-difference and the angular displacement of the sound image, or phantom, from the median plane. The ratio of phase-difference to apparent angular displacement varied with the frequency. A comparison of these ratios was made with the theoretical values as calculated by Stewart and Hartley, but the frequency range was not sufficient to enable final conclusions to be drawn. AUTHOR.

1456. *Quantitative Experiments on Sound under Water.* **H. Barkhausen** and **H. Lichte.** (Ann. d. Physik, 62. 6. pp. 485–516, July 16, 1920.)—The results of these experimental investigations may be summarised as follows:—

1. The energy radiated acoustically by an electromagnetic sender may be determined with an accuracy of about ten per cent.

2. The limiting sensibility of an under-water microphone corresponds to a sound whose intensity is about 10^{-15} watt per cm.^2.

3. The radiation of sound at great distances under water (as in the air) does not follow the inverse square law of the distances, but rather

a damping or attenuation law, *i.e.*, the intensity diminishes in geometrical progression as the distance increases in an arithmetical one.

4. The cause of this is (as in the air) the presence of acoustical inequalities, especially an irregular distribution of temperature.

5. The consequence of this, that the range of sounds under water in summer is in general much less than in winter, is confirmed by experiment.

6. The normal ranges in the free Baltic Sea are in summer about 10 km., in winter 20 km. Near the shores the ranges are less. Occasionally with the same apparatus only 2 km., at other times over 100 km. would be reached, whereas by quadratic radiation without damping a range of over 1000 km. should have been attained.

7. The value of the damping, within the audible frequencies, is independent of the frequency. For quite low frequencies no conclusion was reached on account of the practical difficulties of the experiments.

8. From the law of damping it follows that an improvement in the power of the sending apparatus can have only a negligible influence on the range attained. In practice the range depends much more on the condition of the water. E. H. B.

1457. *Binaural Location of Pure Tones.* I. **G. W. Stewart.** (Phys. Rev. 15. pp. 425–431, May, 1920. Nat. Acad. Sci., Proc. 6. pp. 166–169, April, 1920.)—*Logarithmic law.*—The only published quantitative experiments giving the effect of intensity alone are those of Hovda and the author who found a " logarithmic law," viz., that the effect of intensity only was an apparent angular displacement from the median plane proportional to the logarithm of the ratio of intensities at the ears.

Logarthmic law extended; the value of the " constant."—The law just cited is found to be correct for the three frequencies 256, 512, and 1024 double vibrations, and for a displacement range from 0° to almost 90°. But some individuals (two out of four) do not have a fused tone or phantom source at the frequency last named, and indeed, at other frequencies also. The constant, in the logarithmic law, *i.e.*, the value of the displacement when the log. of the ratio of intensities is unity, is ascertained for several individuals at the above frequencies. For each individual the constant *decreased* with *increasing* frequency.

The experimental method is the one previously used. The logarithmic law is shown not to be an extension of Weber's law, well known to psychologists, but a new law.

Computed values of intensity ratios for given positions of source.—The actual intensities obtaining at the ears when a source of sound is placed at different positions relative to the ears are considered and the theoretical results are plotted and compared with the experimental results.

Intensity not an important factor.—The wide divergence between experimental and theoretical values shows that an explanation in terms of intensity of the ability to locate a pure tone, 256 to 1024 double vibrations is not possible. Intensity cannot be an important factor in localisation of pure tones in this range of frequencies. AUTHOR.

1458. *Binaural Location of Pure Tones.* II. **G. W. Stewart.** (Phys. Rev. 15. pp. 432–445, May, 1920.)—*Linear relation; phase-difference and apparent angular displacement of the source of sound.*—That a linear relation exists between phase-difference at the ears and apparent angular displacement from the median plane between them, is demonstrated for pure tones within the range 100 to 1200 double vibrations. Extended experiments are made with two individuals, but additional evidence is adduced to show that the results have a general applicability.

Linear relation; the variation of the "constant" with frequency.—The "constant" in the above linear relation, or the slope of the curve with the two variables as coordinates, is approximately a linear function of the frequency.

Upper limit of the phase-difference effect.—The upper limit of the phase-difference effect seems to be from 1000 to 1500 double vibrations.

Double images.—It is shown that the phase-difference effect, if it be the controlling factor in localisation, may produce multiple apparent sources. For a frequency of 1024 double vibrations, the double phantom sources are found in actual experiment to have the relative positions indicated by the phase-effect.

Intensity-effect and phase-effect combined.—It is found that when intensity difference and phase-difference at the ears exist simultaneously, neither has a greater effect than when applied separately. Hence quantitative results obtained by using intensity difference only or phase-difference only are transferable to the case of the combination.

Direct perception of phase.—Phase-effect cannot be explained by a direct or by an indirect effect of intensity, for the phase effect at certain frequencies and with some individuals may exist when the intensity effect is wholly absent. Direct perception of phase is thus evident.

Theoretical computation and comparison with experiment.—The phase-difference at the ears for various angular displacements of the source from the median plane are computed for three frequencies scattered over the range under consideration. The relationship is not strictly linear but very roughly so. A comparison is made of the theoretical and experimental ratios of angular displacement and phase-difference. There is a satisfactory quantitative agreement.

Phase-difference the most important factor in localisation.—The significance of the quantitative agreement of experimental and theoretical results is pointed out and the conclusion derived that phase-difference is the most important factor in localisation of the source of a pure tone, 100 to 1200 double vibrations, situated in a horizontal plane in front of the observer and 90° either side of the median plane. This conclusion is extended to include the region behind as well as in front of the observer. There are more factors in actual localisation than in the case assumed in the theoretical discussion; for example, reflection and alterations in quality are doubtless important factors in the general case. Above the limit of the phase-difference phenomenon, viz., approximately 1200 double vibrations, the intensity must become an important factor, but its importance varies with the individual. AUTHOR.

1459. *On the Maintenance of Vibrations of Wires by Electrical Heating.* **N. C. Krishnaiyar.** (Phys. Rev. 14. pp. 490–496, Dec., 1919.)—The amplitude and phase of the vibrations set up in a stretched wire when a single-phase alternating-current of 50 cycles per sec. was sent through the wire have been investigated experimentally, and the results have been compared with the theory given by C. V. Raman.

Amplitude.—(*a*) Sonometer nearly vertical, length of vibrating segment constant, and tension varied by steps. When the tension appreciably exceeded the value corresponding to the free period of the wire no maintained vibrations were established when the current was turned on. As the tension was decreased, persistent vibrations of small amplitude were set up when the resonance tension was approached. The amplitude progressively increased as the tension was decreased through, and some interval below, the resonance tension. Eventually a critical tension was reached at which there was a sudden complete cessation of maintenance. On reversing the process, by gradually increasing the tension, persistent vibrations were not set up unless the wire was strongly plucked at its middle. (*b*) Sonometer horizontal, tension constant, and length of wire decreased progressively. The phenomena observed were essentially the same as in the preceding case.

Phase.—By adapting the principle of the vibration microscope it was observed that the phase of the maintained vibration relatively to the phase of the current was not the same over the whole range of persistent vibrations. The phase changed rapidly by about 90° near the end of the range corresponding to very small amplitudes. For larger amplitudes and over the greater part of the range the phase remained practically constant.

Theory.—When the differential equation of the motion is solved to the first approximation it is found that the square of the amplitude of the vibrations is a linear function of the difference of the squares of the forced and free frequencies. Also the phase should be constant. The experimental curves agree with the theoretical parabolas over all of the range except the portion pertaining to small amplitudes. A like statement applies to the phase. Further work is in progress to throw light on the observed points of inflection, and to account for the discrepancies between theory and experiment. AUTHOR.

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1460. *The Pressure of Sound.* **W. Weaver.** (Phys. Rev. 15. pp. 399–404, May, 1920.)—*Relation between pressure and energy density.*—An argument is given, following a method used by Larmor, to show that a certain general type of radiation will exert a pressure. The pressure of small sound-waves is found to agree with this result, but for finite waves the conditions for the application of the argument are not satisfied. These finite waves do exert a pressure which depends upon the relation between pressure and density, the pressure being zero in a certain important case. This theory has been developed by Rayleigh. It appears, however, that any actual aerial wave does exert a pressure not zero. The pressure on an absorbing sphere is a second-order effect in the product (ak), and is therefore not considered in the usual treatment of spherical obstacles. Waves of energy density of 0·5 erg/cm.^{3} or greater must apparently be treated as finite. AUTHOR.

1461. *The Distribution of Energy about a Point Source.* **P. R. Heyl.** (Phys. Rev. 15. pp. 487–491, June, 1920.)—*Distribution in two dimensions; case of vibrating circular membrane.*—In the case of stationary waves the outline is that of a Bessel's Function, and the energy at the maxima of the successive loops is slightly less than required by the law of the inverse first power of the radius. This departure is perceptible only within a few wave-lengths of the origin. The deficiency at the first loop amounts to 2·5 %, at the sixth to only 0·05 %. At the centre points of the loops a similar law prevails.

Distribution in three dimensions; case of sound in air.—With stationary waves the outline is given by the function $\sin r/r$ whose maxima follow a law similar to that of the Bessel's Function, with a slight departure from the law of the inverse square. The departure from the result calculated from this law is about 5 % in the first loop, but only 0·5 % in the fourth loop. At the central points of the loops the law of the inverse square is accurately followed. With running waves, the same displacement of maxima exists, but the time integral of the energy of any loop at a given point is proportional to $1/r^2$ as the conservation of energy demands.

Suggestions.—Departures of this nature from simple and well-founded laws are sometimes required by fact, as in astronomical theory, but have heretofore not been furnished by classical physical theory. This suggests further possibilities of critical study of the older mechanics. AUTHOR.

1462. *Stroboscopic Equations.* **L. E. Dodd.** (Phys. Rev. 15. pp. 145–146, Feb., 1920. Abstract of paper read before the Am. Phys. Soc., Nov., 1919.)—Quotes various writers and their equations, namely: Poske, $m = l \pm 1/s$; Michelson, $n = N \pm 1/s$; Reed, $Nt = n \pm c$; where the m, n, and N on the left side are frequencies of the test fork, while s and the reciprocal of c, on the right side refer to the period of the image cycle or optical beat. The above are cases of a more general form which may be written: $\mu n - \nu m = 1/2\tau$, or, $f = mA - nB$; where μ/ν is a fraction at lowest terms expressing the nearest whole-numbered approximate ratio of the two fork frequencies n and m, and τ is the half-period of the beat; f is the frequency with which simple stroboscopic images pass the tonoscope scale, A the frequency of dots in a given row on a rotating drum, B the frequency of illumination. E. H. B.

ELECTRICITY AND MAGNETISM.

THEORY, ELECTROSTATICS, AND ATMOSPHERIC ELECTRICITY.

1463. *On Electromagnetic Momentum.* **H. A. Wilson.** (Phys. Rev. 16. pp. 17–30, July, 1920.)—*Fundamental relations involving electromagnetic momentum.*—A simple way of deducing the force per unit volume acting in the electromagnetic field is given which makes clear the nature of the force in terms of elementary ideas. The well-known relation between the *flux of energy* and the momentum in the field suggests that all momentum is due to energy flux. Starting with this assumption a simple relation is obtained between the momentum, energy, and *velocity of the centre of mass* of any system. This relation when applied to a single particle leads to the same relations between the longitudinal and transverse *masses* and the velocity as have been deduced from the principle of *relativity*. Several particular examples are discussed.

Relations of matter and ether to stresses.—It is argued that since the electromagnetic field has momentum, energy, and is subject to *gravitational attraction*, it therefore possesses all the essential properties of matter and that therefore the *stresses* in the field should be regarded as acting through the field and on it in the same way that stresses act in ordinary matter. When there is a resultant force on a space containing matter the force is supposed to act on the matter and not on the ether in the space, and the motion of matter and the stresses in it are not supposed to act on the ether or to tend to set it in motion. We should therefore regard the stresses in the electromagnetic field as acting on the field and not on the ether. There is therefore no more reason to suppose that the ether is set in motion in an electromagnetic field than there is for supposing that it is set in motion by the stresses in or the motion of ordinary matter.

The transmission of energy and momentum in the field.—This is considered from the point of view indicated. The theory is similar to that given by E. Cunningham, who, however, regards the motion in the field as motion of the ether. Cunningham also supposes that the velocity is always equal to the velocity of light. The author has not adopted this assumption, but instead he supposes that the direction of the velocity of the field coincides with the direction of the momentum in the field. In this way the *flux of energy* in the field is explained as partly due to the working of the stresses in the field and partly to *convection of energy* with the moving field. Several examples are discussed. Finally some results are mentioned which follow from the idea that energy is subject to *gravitational attraction*. AUTHOR.

1464. *Electrical Disturbances due to Tides and Waves.* **F. B. Young, H. Gerrard,** and **W. Jevons.** (Phil. Mag. 40. pp. 149–159, July, 1920.)—The authors record the results of experiments carried on outside the mouth of the Dart in 1918, incidental to objects of immediate practical importance, which showed that certain electrical disturbances could be definitely traced to movement of sea-water in the earth's magnetic field. Faraday (Bakerian Lecture, 1832) has described his attempts to obtain evidence of the e.m.f.'s which should be produced across the Thames by its flow across the earth's vertical magnetic field, but he was able only to detect some irregular disturbing effects. The authors point out that the null result may probably have been due to the combination of a nearly uniform velocity over the cross-section of the stream with an earth return of low resistance and an absence of currents generated at a distance, which would result in a sensibly uniform potential across the stream. The authors' experiments were made with both moored and towed electrodes, the latter being 100 to 200 yards apart, and the former about 2000 yards. A Paul recording galvanometer served as voltmeter in the latter case and a unipivot galvanometer, specially balanced for use at sea, in the former. The results obtained clearly indicate the existence of periodic e.m.f.'s in the sea, whose period and magnitude show them to be the result of earth induction in tideways. The high values obtained with drifting electrodes show that the e.m.f.'s due to purely local inductions which are measured by moored electrodes must be small, and that the e.m.f.'s actually obtained with these electrodes are due mainly to more remote tidal currents, a view supported by the phase-differences observed. This simply means that the tidal "dynamo" is almost completely short-circuited by the earth return, a condition which might be expected. It is pointed out that for complete measurements pairs of moored electrodes stationed on lines at right angles to each other are required, and also that the experiments with moored and drifting electrodes should proceed simultaneously and in the same area in order that the results may be correlated. The experimental results are prefaced by a brief discussion of the theory of the subject. The observations suggest that each locality may be subject to an "electromagnetic tide" approximating in regularity to the sea tides. G. W. de T.

1465. *Experiments in Contact Electricity.* **A. Coehn** and **A. Lotz.** (Phys. Zeits. 21. pp. 327–329, June 15, 1920.)—(1) In order to show that mere contact and separation of two unlike non-conductors, without rubbing, suffices to produce electrification, choose as suitable materials paraffin wax and distilled water. The former is used as a thin layer on a metal sphere, the latter is in a vessel into which the waxed sphere can be dipped. The sphere is attached to an electroscope. The negative charge, produced on the sphere by contact with the water, can be removed by bringing a small flame near it, leaving a positive charge. As a variation of the experiment, coat a metal runnel with paraffin and allow water to run down it, drop by drop. The runnel is connected by a conductor to an electroscope; and the water, after its passage down the runnel, is caught on another electroscope.

(2) Various experiments can be performed with a glow-lamp, or, better, quartz-mercury lamp. These can be made to fluoresce by (i) friction with rubber on the lamp, or (ii) the action of strong charges on rubbed quartz near at hand, or again (iii) the action of an influence machine even at several metres. Ionisation of the gas enclosed in the lamp occurs in each case. P. E. S.

DISCHARGE AND OSCILLATIONS.

1466. *Free Path of Hydrogen Canal-Rays in Hydrogen and Oxygen.* **A. Rüttenauer.** (Zeits. f. Physik, 1. 4. pp. 385–392, 1920.)—By determining the ratio of positively charged " H " rays to the total canal-ray stream, at different pressures and voltages in the discharge tube, the author deduces a value for the free path of the " H " rays in hydrogen and in oxygen. For this purpose a formula developed by W. Wien [Abs. 1548 (1911)] is employed. A. B. W.

1467. *Theory of Probability in Electron Emission.* **E. Schrödinger.** (Akad. Wiss. Wien, Ber. 128. 2a. pp. 177–237, 1919.)—Gives a discussion of the problems in probability arising in the theory of discontinuity in electron emission advanced by E. v. Schweidler [see Abs. 1458 (1910)]. J. W. T. W.

1468. *Symmetrical Subdivision of Anode Glow in Helium Discharge Tubes.* **G. M. J. Mackay.** (Phys. Rev. 15. pp. 309–311, April, 1920.) —*Symmetrical luminous patterns formed on anode by electrical discharge through helium. Description of experiment.*—When a continuous electrical discharge passes through helium at a pressure of 2 cm., the anode glow may break up into a number of spots more or less regularly distributed. The most striking arrangement is the three-ring type with one spot at the centre of a regular pentagon, which in turn is surrounded by eleven other spots uniformly distributed about the circumference of the circular anode, which is 2·7 cm. in diameter. AUTHOR.

1469. *Kathode-Fall in Neon.* **A. H. Compton** and **C. C. Van Voorhis.** (Phys. Rev. 15. pp. 492–497, June, 1920.)—Systematic measurements have been made of the p.d. between the kathode and the beginning of the positive column when a discharge is passed through pure neon, using a number of different metals as kathode. The " normal kathode fall," or p.d. between the kathode and the kathode glow for normal current, was also determined for several metals. It was found that for normal current the p.d. between the kathode and the positive column is very nearly proportional to the p.d. between the kathode and the kathode glow when different metals are used as kathode. The values of the normal kathode-fall in neon were found to be: with Pt kathode 152 volts, W 125, Tl 125, Al 120, Mo 115 (?), Mg 94, Ca 86, Na 75, and K 68 volts. These values are in the order, as far as available data go, of the contact potential series, and are consistently slightly lower than the corresponding values in helium. AUTHORS.

1470. *Ionisation by Successive Impacts, and its Action in Low-Voltage Arcs.* **K. T. Compton.** (Phys. Rev. 15. pp. 476–486, June, 1920.)—*Theory.*—Stark has shown that the energy acquired by an atom when struck by an electron whose speed exceeds the critical value usually expressed in terms of the minimum radiating potential, may be retained for a short interval of time before being lost by radiation, or otherwise. It is assumed that ionisation may occur if a second impact occurs within this time interval, provided the sum of the energies of the two electrons exceeds that corresponding to the minimum ionising potential. Expressions are derived for the *total ionisation, intensity of radiation* and *increase in total current when an arc strikes* due to successive impacts.

Low-voltage Arcs; theory.—Arcs at abnormally low voltage may be accounted for by successive impacts. *Comparison with experiments* by McLennan on the mercury arc is made.

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It is shown that the phenomena cannot be adequately explained by single impacts of electrons which, for one cause or another, have acquired abnormally high speeds. A combined action of radiant energy and energy of impact may be important. AUTHOR.

1471. *Fundamental Phenomena in Electron Tubes with Tungsten Kathodes.* **I. Langmuir.** (Gen. El. Rev. 23. pp. 503–513, June, and pp. 589–596, July, 1920.)—In the first part of this paper a discussion is given of the electron emission and the space charge effect in electron tubes. In the second part the secondary electron emission from the walls of the tube is dealt with, and it is shown how the various fundamental phenomena and subsidiary effects co-operate to determine the operating characteristics of such tubes. A. W.

1472. *Input Impedance of the Thermionic Amplifier.* **S. Ballantine.** (Phys. Rev. 15. pp. 409–420, May, 1920.)—At low frequencies the input circuit of the three-electrode vacuum tube behaves as a pure capacity. At radio frequencies, due to the inherent capacity of the grid and plate electrodes, the *input impedance resembles the combination of a condenser shunted by a resistance or conductance.* The effective capacity and effective conductance are then functions of the load in the plate circuit. In the case of a resistance connected in this circuit, the conductance is positive and represents a loss. An *inductance load manifests itself in a negative conductance* and thus supplies energy from the plate to grid circuit. These *feed-back effects* are *occasioned solely by the grid-plate capacity* and depend upon its magnitude.

The phenomena described are investigated analytically, and expressions are developed for the values of the effective capacity and conductance for various loading conditions. The physical significance of the equations is depicted by a series of curves, plotted for the various load configurations of the analysis. One set of curves shows the conditions which favour feed-back action and suggests the *principles which should govern the design of amplifying tubes.* Equations are developed which are of practical value in *choosing proper inductances for regenerative receiving circuits.* The desirability of so designing tubes as to *avoid excessive grid-plate capacity* is emphasised. Other curves show the variation of input inductance and capacity with pure resistance load. The reason for the failure of many radio-frequency cascade amplifier arrangements is at once evident from the conclusions. AUTHOR.

1473. *Effect of Ionisation on Characteristic of a Valve containing a Trace of Gas.* **B. Hodgson** and **L. S. Palmer.** (Radio Rev. 1. pp. 525–531, Aug., 1920.)—The characteristics considered were obtained by maintaining the grid of a three-electrode valve at a constant potential v positive with respect to the negative end of the filament, and varying the anode potential V. The grid current i and anode current I are thus obtained as functions of V (v being constant). With a hard valve the value of i increases as the anode potential increases up to the value $V = 0$, and then steadily decreases. With a valve containing a trace of gas, however, the grid current, with V positive and increasing, does not decrease continuously, but at a certain point begins to increase again. This is due to ionisation, and the results may be used to determine the ionisation potential for the gas in the valve. The method does not claim to be a precision method, but it gives results in good agreement with those obtained by other observers. Four different types of valve gave the following ionisation potentials: mercury vapour, 10·4 volts; nitrogen, 17·4 volts; argon, 16·6 volts; helium, 21·9 volts. A. W.

1474. *Phenomena in Oxide-coated Filament Electron Tubes.* **H. D. Arnold.** (Phys. Rev. 16. pp. 70-82, July, 1920.)—*Thermionic phenomena in Wehnelt oxide electron tubes.*—The author discusses some of the problems which have arisen in connection with the development of three-electrode vacuum tubes with special reference to the production of a highly active and uniform thermionic source of electrons. The materials and the methods for the preparation of both core and coating are given. Since tubes with these filaments are not self-evacuating by the clean-up effect to the extent found with tungsten filaments, greater care is necessary in the pumping process.

Pure electron discharge; the influence of pressure and of bombardment by positive ions.—The evidence shows the electron emission from Wehnelt oxides to be purely thermionic. Preliminary measurements on the number of electrons emitted from these filaments under the bombardment of positive ions prove that no appreciable part of their activity can be attributed to this cause. Operation has been studied with pressures of the order of 10^{-10} mm. Hg, but no decrease in activity is found at these low pressures. A plot is given summarising the constants of Richardson's equation for 4000 filaments.

Rate of evaporation of oxide coating.—The amount in gm. per cm.^{2} per sec. evaporated from a filament coated by the above process is approximately given by

$$m = 4{\cdot}6 \times 10^8 T^{-1/2}\epsilon - \frac{4{\cdot}6 \times 10^4}{T}.$$

Thinly coated filaments; coating by evaporation.—Preliminary results of work now being carried on by C. J. Davisson show that max. thermionic activity may be reached with coatings considerably less than one molecule deep. This suggests that of the two important constants determining electron emission, the density of free electrons in the substance and the work function at the surface, the latter is modified by the presence of the oxides while the former may remain essentially that of the core. AUTHOR.

1475. *Transmission of Electric Waves round the Earth.* **B. van der Pol, Jr.** (Phil. Mag. 40. p. 163, July, 1920.)—The author calls attention to a numerical error, pointed out to him by G. Vallauri, in his expression for the current generated in a receiving antenna, as a function of the constants of a transmitting station and of the angular distance between transmitter and receiver, given in a former paper [Abs. 429 (1920)]. This does not, however, affect the conclusion there arrived at that, assuming the atmosphere to be a perfect insulator, we obtain values for the wave amplitude at a great distance from a transmitting station differing widely from the experimental results. G. W. DE T.

1476. *Three Magnetically-coupled Circuits.* **E. Bellini.** (Electrician, 85. p. 78, July 16, 1920.)—This paper gives the theory of three oscillating circuits, of the same fundamental frequency, magnetically coupled in series and supposed to possess zero resistance. The method employed is that of repeated differentiations. The theory and experiment show (1) that the intermediate circuit possesses two periodicities $m_1 = m/\sqrt{(1 + K)}$ and $m_2 = m/\sqrt{(1 - K)}$, where m is the natural periodicity of the circuits before coupling and $K = \sqrt{(K_{12}^2 + K_{23}^2)}$, K_{12} and K_{23} being the coefficients of coupling between the circuits 1–2 or 3–4 respectively; and (2) that the extreme circuits possess in addition to the periodicities m_1 and m_2, the periodicity m.

The case of the intermediate circuit being non-oscillatory is further considered and furnishes the result that the intermediate circuit possesses only the periodicity $m_1 = m/\sqrt{(1 - K^2)}$, whilst the extreme circuits possess both the periodicities m and m_1. **L. C. Pocock** (*Ibid.*, p. 161, Aug. 6, 1920). E. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

1477. *The "Thalofide" Cell—A new Photoelectric Substance.* **T. W. Case.** (Phys. Rev. 15. pp. 289–292, April, 1920.)—A new photoelectric cell is described which is composed of thallium, oxygen, and sulphur. This cell shows maximum sensitiveness to light of wave-length about 10,000 Å.U. Some of the best cells lower their dark resistance by 50 % in 0·06 candle-ft. when the light source is a tungsten filament. The dark resistance of different cells may be from 5 to 500 megohms. The induction and deduction periods of the cells are very small. The chief characteristics of the cell are mentioned. AUTHOR.

1478. *Thermionic Vacuum Tube as Detector, Amplifier, and Generator of Electrical Oscillations.* **W. H. Eccles.** (Electrician, 84. pp. 522–524, May 7, 1920. Abstract of lecture delivered at the Roy. Inst. Engineering, 109. pp. 724–725, May 28, 1920.)

1479. *Measurement of Received Radio-telegraphic Currents with the Electrometer.* **E. O. Hulburt** and **G. Breit.** (Phys. Rev. 15. pp. 405–408, May, 1920.)—*Measurement of received radio currents.*—A new method has been developed for the accurate measurement of received currents in radio telegraphy by means of the *quadrant electrometer connected in the plate circuit of an electron tube* which is used either singly or as the detector tube of a multi-stage amplifier.

Calibration of the Apparatus.—In order to employ such an arrangement to measure signal intensity the relation between electrometer deflection and effective input voltage must be known, and a *condenser potentiometer* for such a calibration has been devised. AUTHOR.

1480. *Unipolar Conductivity of Crystals.* II and III. **F. Streintz** and **A. Wesely.** (Phys. Zeits. 21. pp. 316–321, June 15, and pp. 367–374, July 15, 1920.)—Earlier work on lead-glance has previously been given [Abs. 912 (1920)]. The second part of this paper gives results of similar work for silver-glance, which confirm the conclusions arrived at before. The third part discusses the effect of temperature on polarity, and gives the results of thermoelectric measurements made with lead-glance and lead. The following equation is in close agreement with the observations, which extended over a temperature range from 10° C.

to 80° C., namely: $\pi = 143{\cdot}70(t_2 - t_1) + 0{\cdot}235(t_2^2 - t_1^2)$ microvolts. Compared with a Bi-Sb couple the thermoelectric effect with lead and lead-glance is about three times greater. A. W.

1481. *High-tension D.C. Apparatus.* **D. L. Webster.** (Nat. Acad. Sci., Proc. 6. pp. 269–272, May, 1920.)—In a recent paper on X-rays [Abs. 724 (1920)] the author has described a high-tension d.c. outfit based on that of A. W. Hull, with certain changes of details. On further investigation it appears that one of these changes introduces a disturbing factor. The present note deals with this disturbance and suggests means of eliminating it. A. B. W.

1482. *On a Micro-Voltameter.* **C. T. R. Wilson.** (Cambridge Phil. Soc., Proc. 19. p. 345, Feb., 1920.)—Experiments are described with a mercury voltameter, in which one electrode consists of a sphere of mercury deposited on the end of a fine Pt wire and measured by means of a microscope. Quantities of electricity varying from a few hundred electrostatic units to about one coulomb may be measured by it. The almost instantaneous change of size of the drop when a capacity of $\frac{1}{10}$ mfd., charged to 1 volt, is discharged through the instrument is easily observed. A magnet inserted in or removed from a coil connected to the terminals of the voltameter produces an easily measured effect. Experiments were also mentioned which suggest the possibility of its application in measurements of much smaller electrical quantities.
AUTHOR.

1483. *Energy Ratios in a Circuit with Self-Induction.* **P. Terpstra.** (Phys. Zeits. 21. pp. 467–469, Sept. 1, 1920.)—This paper gives a graphical treatment of the energy relationships in a circuit possessing self-inductance and resistance but no capacity. A. W.

1484. *Effect of Various Elements on the Electrical Resistivity of Iron.* **A. L. Norbury.** (Iron and Steel Inst., J. 101. pp. 627–644, 1920.)—In the first part of the paper the author summarises the work on the electrical resistivity of iron up to the year 1902, concluding with the formula proposed by Benedicks for calculating the resistivity of a steel from a knowledge of the carbon equivalent (C) of the foreign dissolved elements. Iron carbide out of solution was presumed to have no appreciable effect on the resistivity. Recent work has shown that the applicability of Benedick's formula, namely, $R\ (\text{microhms-cm.}) = 7{\cdot}6 + 26{\cdot}8\sum C$ is limited. The least value found for the resistivity of pure iron is of the order 9 microhms-cm.; the presence of $0{\cdot}004\,\%$ of hydrogen in solution would reduce this to 7·6 as required by Benedicks' equation.

The work of later investigators is then discussed under the following heads: (*a*) Influence of carbon on the resistivity of annealed C steels; (*b*) its influence on quenched steels; (*c*) resistivity of pure iron. In the case of annealed carbon steels the linear law apparently holds, although the results of different observers vary somewhat, probably due to the different conditions of annealing. They indicate, however, that practically all the cementite can be got out of solution by suitable annealing. In the case of quenched steels the resistivity is not a linear function of the equivalent carbon content. It is concluded that 9·9 microhms-cm. is to be taken as the resistivity of pure iron at 20° C.

Researches on the influence of other elements including N, Al, Bi, P, V, Cr, Mn, Ni, Co, Cu, Mo, W, Au is then considered. The binary alloy systems admit of simple explanation. Up to 1 % added element going into solution the increase in resistivity is a linear function of the composition. For higher percentages the curvature becomes marked. A table of results is compiled which shows that equiatomic quantities of different elements dissolved in iron do not increase the resistivity by the same amount; a factor depending on the electronic properties of the particular element in solution being probably of influence. This factor is apparently related to the difference between the decomposition potentials of the solvent and the solute. The table is used to calculate the resistivity of a number of steels investigated by Campbell. The amount of foreign elements in solution in these particular steels was small, and the numbers calculated from the table agree more nearly with the observed values than those obtained by using Benedicks' equation.

The ternary alloy systems of Fe and C with most of the metals are very complex and have not yet been fully investigated. L. L.

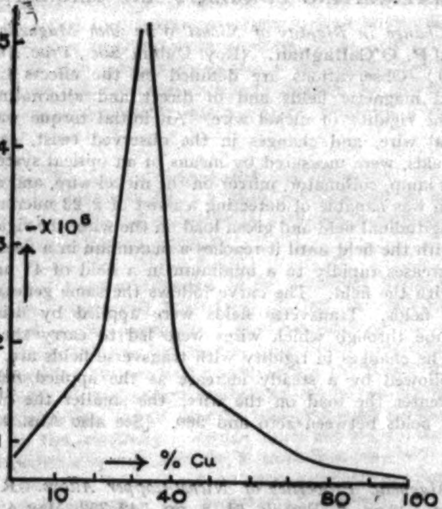
ALTERNATING CURRENTS AND MAGNETISM.

1485. *Change in Rigidity of Nickel Wire with Magnetic Fields.* **W. Brown** and **P. O'Callaghan.** (Roy. Dublin Soc., Proc. 16. pp. 98–104, Aug., 1920.)—Observations are detailed on the effects of alternating longitudinal magnetic fields and of direct and alternating transverse fields on the rigidity of nickel wire. An initial torque was applied to a horizontal wire, and changes in the observed twist, caused by the magnetic fields, were measured by means of an optical system consisting of a Nernst lamp, collimator, mirror on the nickel wire, and a microscope. This system was capable of detecting a twist of 2·22 microradians. For a direct longitudinal field and given load on the wire, the rigidity of nickel increases with the field until it reaches a maximum in a field of 26 c.g.s.; it then decreases rapidly to a minimum in a field of 41 and thereafter increases with the field. The curve follows the same general shape with alternating fields. Transverse fields were applied by using a slotted soft-iron tube through which wires were led to carry the magnetising current. The changes in rigidity with transverse fields are, first a slight decrease followed by a steady increase as the applied field increases; also the greater the load on the wire, the smaller the change in the rigidity for fields between zero and 960. [See also Abs. 477 (1907).]

G. E. A.

1486. *Magnetic Properties of Nickel-Copper Alloys.* **R. Gans** and **A. Fonseca.** (Ann. d. Physik, 61. 8. pp. 742–752, May 4, 1920.)—The alloys were produced by melting the pure metals in an electric furnace of the Ruer type in which the current flowed along a hollow carbon tube containing the metals in a magnesia dish. An alternating current was supplied by a 6-kw. machine and had a max. value of 150 amps.; this was transformed to obtain a larger current. Short bars of the alloys were hung up between the poles of a Du Bois electromagnet at 45° to the direction of the field, and the deflections of the bars were observed at temperatures varying between −230° and + 55° C. The temperature-Ni content curve shows a discontinuity between 45 % and 50 % Ni. The observations of B. Hill and of Guertler and Tammann are also plotted, and, in the main, these confirm and amplify the authors' results [see Abs. 2262 (1902) and 344 (1907)]. The susceptibility of the alloys is then measured at 15° C. by the method of Weiss and Foëx for Ni percentages from 20·3 to 60·2, for which extremes the specific susceptibilities are respectively $0{\cdot}038 \times 10^{-6}$ and $4{\cdot}565 \times 10^{-6}$; above 60·2 % the alloys may be regarded as ferromagnetic. The susceptibility-nickel content curve also exhibits a break between 45 % and 50 % Ni. There is a similar effect in the electric conductivity and temperature coefficient of these alloys (Feussner and Lindeck, 1895) which points to the existence of a compound with the formula CuNi. The authors' experiments indicate that, contrary to Tammann's rule [Abs. 905 (1909)], ferromagnetic crystals dissolved in non-magnetic crystals can form ferromagnetic alloys. The behaviour of the Ni-Cu alloys is very similar to that of the Co-Cu alloys. G. E. A.

1487. *Magnetic Susceptibility of Copper-Zinc Alloys.* **R. H. Weber.** (Ann. d. Physik, 62. 7. pp. 666–672, Aug. 4, 1920.)—This paper contains the results of measurements made by K. Greulich on the magnetic susceptibility of copper-zinc alloys. An alloy containing 32·78 % Cu shows a max. susceptibility (χ) of $-5{\cdot}694 \times 10^{6}$ indicating the existence of a compound $CuZn_2$. Hitherto measurements of the resistivity of Cu-Zn alloys have pointed to the existence of a compound CuZn. L. L.



1488. *Molecular Theory of the Paramagnetism of Solid Salts.* **O. Stern.** (Zeits. f. Physik, 1. 2. pp. 147–153, 1920.)—Starting from the fact that Curie's law, according to which the susceptibility is inversely

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proportional to the absolute temperature, holds also for many solid salts, Weiss has applied Langevin's theory of this law to solid substances, the assumption being made that in this case also the molecules, as carriers of the elementary magnets, are freely rotatable; although the falsity of this assumption is clearly shown by the characteristic anisotropy of crystals, this molecular theory of the paramagnetism of solid salts has been employed by recent investigators as the foundation for far-reaching conclusions. Weiss attempted to show later that the assumption of free rotation is unnecessary if the molecules may be regarded as joined to stable equilibrium positions or as capable of oscillating round these owing to temperature changes, provided only that, as in amorphous substances and crystalline powders, such equilibrium positions are not preferably in any particular direction. The author finds that this result obtained by Weiss depends on an error of calculation and now subjects the problem to new analytical treatment. In the result it is found that the susceptibility is, as a first approximation, independent of the temperature, and as a second approximation, decreases slightly as the temperature rises. Such a result could, indeed, have been predicted without calculation. Curie's law is, therefore, invalid for molecules oscillating about an equilibrium position, free rotation of the molecules being essential. Since the molecules in a crystal are certainly not freely rotatable, and since also Curie's law is found experimentally to be applicable to crystals, it follows that the molecules as such cannot be the carriers of the magnetic moment; this function is probably performed by the ions. T. H. P.

1489. *Diamagnetism due to Free Electrons.* **H. A. Wilson.** (Roy. Soc., Proc. 97. pp. 321–326, June 1, 1920.)—In this paper it is shown that the presence of free electrons in a metal should produce diamagnetic susceptibility of amount comparable with that found in the diamagnetic metals. The total susceptibility of metals is therefore presumably equal to the sum of that due to the atoms, which may be paramagnetic or diamagnetic, and that due to the free electrons. The electrons tend to circulate about an axis parallel to a magnetic field (H) in which the metal is placed, and the author calculates an approximate expression for their angular momentum about this axis, assuming that the velocities of the electrons are distributed according to Maxwell's law. The motion of electrons with this angular momentum produces a magnetic field in a direction opposite to the external field, and calculating this, the magnetic moment per unit volume, I, may be obtained. This gives the susceptibility $s = \mathrm{I}/\mathrm{H} = -\frac{1}{3}ne^2\lambda^2/m(1 + \omega^2\mathrm{T}^2)$, where n is the density of electrons, e the charge on and m the mass of an electron, T the mean interval of time between two collisions, λ the mean free path of an electron, and $\omega = \mathrm{H}e/m$. For most diamagnetic metals $\omega\mathrm{T}$ is small and $s = -\frac{1}{3}ne^2\lambda^2/m$ approximately. In this case s should not vary much with temperature. At very low temperatures, however, $\omega\mathrm{T}$ cannot be neglected and s should diminish and become zero at the absolute zero of temperature.

The results obtained are discussed with those of the electron theory of the optical and electrical properties of metals. The theory clearly indicates that free electrons should produce diamagnetic susceptibility, but the electron theory of metals is not in a sufficiently satisfactory condition to provide reliable data for comparison. T. H.

1490. *Magneto-Resistance Effects in Bismuth Films.* **J. A. Becker and L. F. Curtiss.** (Phys. Rev. 15. pp. 457–464, June, 1920.)—*Magneto-resistance effects in films of bismuth: an experimental investigation.*—Films of bismuth were deposited on glass by kathodic sputtering. These films showed initially no change of resistance when placed in a magnetic field of 16,000 gauss. It was found that by heating to a temperature near the melting-point of Bi this property could be partially restored. This change in the film as a result of heating seemed to be accompanied by a crystallisation of the metal as indicated by photomicrographs. The films had a negative temperature coefficient of resistance. AUTHORS.

1491. *Magneto-Resistance Effects in Bismuth Films.* **F. K. Richtmyer and L. F. Curtiss.** (Phys. Rev. 15. pp. 465–475, June, 1920.)—*Increase of resistance of bismuth films in a magnetic field; the effect of heat treatment.*—Films of Bi 1 cm. long by 3 mm. wide were sputtered from chemically pure Bi on glass slides to resistances varying from 25 to 200 ohms. If especial care is taken to avoid heating these films during the sputtering, by allowing the process to go on intermittently at short intervals, there is little or no change produced in the resistance of such films when placed in a transverse magnetic field of 16,000 gauss. If the films are heated to a temperature near the melting-point of Bi and allowed to cool and this process repeated several times, after each heating the film exhibits a greater change of resistance in the magnetic field than before it, until a certain upper limit is reached, beyond which further heating, if the previous max. temperature is not exceeded, has little effect. Likewise, heating to successively higher temperatures, beginning at a fairly low maximum and gradually approaching the melting-point of the metal in each successive heating, restores the property under investigation to a greater and greater degree. Heating to temperatures under 150° has very little effect towards restoring this property, while heating to temperatures above this value has a correspondingly larger effect. If the film is strongly heated while being sputtered the initial increase of resistance in the magnetic field is comparatively large and further heating produces only slight increases in this initial value. The increase of resistance in weak fields or where the total effect is not large is strictly proportional to the square of the field strength.

Negative temperature coefficient.—The heating as above described produces no observable change in the negative temperature coefficient of resistance of these films, which was carefully measured before and after each heating. AUTHORS.

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CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

1492. *Helium and Parhelium.* **J. Franck** and **F. Reiche.** (Zeits. f. Physik, 1. 2. pp. 154–160, 1920.)—From comparison of the calculated and observed values for the ionisation potential of helium [Abs. 251 (1920)] the conclusion has been drawn that the observed value relates to the less stable helium atom with the crossed electronic orbits [see Landé, Abs. 504 (1920)] and that this atom, *i.e.*, parhelium, represents normal helium. From the proof that the line 1·083 μ belonging to the system of coplanar helium is a resonance line, it is shown with certainty that in normal helium only the crossed unstable system is present. These conclusions lead to various consequences concerning the so-called metastability of the diquantic coplanar helium. T. H. P.

1493. *Adsorption of Nitrogen and Oxygen by Charcoal.* **R. E. Wilson.** (Phys. Rev. 16. pp. 8–16, July, 1920.)—*Discussion of previously published results.*—This paper is based on experimental data by Lemon and Blodgett [Abs. 450 (1920)].

Definite relationship between mols of oxygen, nitrogen, or mixtures adsorbed.—Attention is called to the surprising fact, hitherto not mentioned, that the number of mols of oxygen adsorbed to any given final pressure is almost exactly 1·30 times the number of mols of nitrogen adsorbed to the same final pressure. The pressure *vs.* volume adsorbed curve for pure oxygen and for mixtures of oxygen and nitrogen can, therefore, be very accurately calculated from the results obtained with nitrogen alone. Furthermore, it is also possible to reproduce all the curves representing the *rate* of adsorption from the results obtained with nitrogen alone.

Bearing of foregoing relationship on theory of adsorption; nature of forces by which gas molecules are held.—By a mathematical treatment of the foregoing data, it can be demonstrated that neither Langmuir's one-layer adsorption theory (which undoubtedly applies to that portion of the gas held with the greatest tenacity) nor the "capillary condensation theory" (which applies to loosely held liquid in capillaries of moderate size) is applicable to the intermediate range of pressures covered by Lemon and Blodgett's data. Their results can, however, be explained on the basis of the following hypothesis: (1) the ratio of the molecular volume of adsorbed nitrogen to that of adsorbed oxygen is the same as for the free liquids (1·31 at − 192° C.); (2) the gases are held in layers several molecules deep primarily by the attractive force of the charcoal surface; (3) the stray field around oxygen and nitrogen molecules is substantially the same at any given distance. AUTHOR.

1494. *Atomistics.* X. [VIII. ?] *Space-filling and the Scale of Corresponding States.* **R. Lorenz.** (Zeits. Anorg. Chem. 103. pp. 243–248, July 12, 1918.)—If ϕ be the volume of the ions calculated from the ionic mobility, and V the volume derived from the density or by Kopp's formula, then ϕ/V_0 is the space-filling number referred to absolute zero on the empirical scale of the law of corresponding states. The author and Posen have calculated these numbers for over a hundred kations and anions and inorganic salts [Abs. 986 (1917)]; the values ranged from

0·37 to 0·60, the mean being 0·4668. Referring the suffixes *s*, *k*, *e* respectively to boiling, critical, and melting points, the author further deduced $V/V_s = 0{\cdot}214T/T_s + 0{\cdot}709$ for solids, and $V/V_s = 0{\cdot}453T/T_s + 0{\cdot}546$ for liquids, $V_0/V_s = 0{\cdot}709$ (mean) and $\phi/V_s = 0{\cdot}331$. Thus he finally finds $\phi/V = 0{\cdot}331/(0{\cdot}214T/T_s + 0{\cdot}709)$, for solids, and similarly for liquids, and deduces empirically an equation of state for ϕ depending merely on temperature.

IX. *Space-filling and the mobility of univalent organic ions.* (*Ibid.*, 105. pp. 175–186, April 3, 1919.)—The ionic radius of the ions studied is a linear function of the number of atoms in the ion. When this number of atoms is about 27, the radius is normal, and has then the dimension $2{\cdot}8 \times 10^{-8}$ cm.; smaller (greater) numbers of atoms lead to smaller (greater) radii according to Hevesy [see Abs. 961, 962 (1919)]. An ion in solution tends to attain a normal potential which in aqueous solutions is about 70 millivolts for a normal univalent ion; smaller ions (of fewer atoms) diminish their potential to this normal value by combining with water. The author does not find any evidence, however, of this particular hydration, nor that the number 27 atoms should have any special significance. The relation between the ionic radius and the number of atoms is linear, and there are no discontinuities in the curves of ionic radii or of the space-filling numbers; the space-filling numbers of univalent ions with more (fewer) than 27 atoms are 0·474 and 0·388 respectively, and the mean value for the "ideal univalent organic kation" with from 4 to 50 atoms is approximately 0·40. The number 0·474 is regarded as reliable, because those ions cannot be hydrated according to Hevesy. H. B.

1495. *Separation of the Isotopes of Chlorine.* **D. L. Chapman.** (Nature, 105. pp. 487–488, June 17, 1920.)—The author shows, if certain plausible assumptions are made concerning the nature of chemical equilibria and the properties of isotopes, that it should be possible to separate the isotopic varieties of an element like chlorine by means of a reversible chemical change in the gaseous state, provided that the number of atoms of chlorine in the reacting compound is unequal to the number of atoms in the resulting compound. Attempts are being made to realise such separation of the isotopes of chlorine. **F. Soddy.** (*Ibid.*, p. 516, June 24, 1920.)—Chapman's conclusion that, on certain assumptions, the isotopes of chlorine should be capable of separation by chemical means, is shown to be erroneous. T. H. P.

1496. *Universal Isotopy.* **A van den Broek.** (Phys. Zeits. 21. pp. 337–340, July 1, 1920.)—An empirical treatment of the isotopy of all the "elements" in the periodic system. A. B. W.

1497. *Separation of Isotopes of Chlorine.* **F. Soddy.** (Nature, 105. pp. 642–643, July 22, 1920.)—The author applies thermodynamical reasoning to the question of the possibility of separating the isotopes Cl_2, Cl^1_2, and ClCl. Probability considerations are also applied to the kinetics of the reaction between the three isotopes. The original paper should be consulted. **A. F. Core.** (*Ibid.*, p. 677, July 29, 1920.)—Core discusses the question from the point of view of entropy, and criticises certain suggestions made by Soddy. A. B. W.

1498. *Bismuth Hydride.* **F. Paneth.** (Zeits. Elektrochem. 24. pp. 298–299, Oct. 1, 1918.)—A bismuth hydride, analogous to the hydrogen compounds of As and Sb was not known. Bismuth, itself not radioactive, has four radio-active isotopes, however: RaC, ThC, ActC, and RaF; and from an alloy of magnesium and RaC the author has liberated a bismuth hydride. *Bismuth Hydride and Polonium Hydride.* I. **F. Paneth.** (Ber. Deutsch. Chem. Ges. 51. pp. 1704–1728, 1918.)—The alloy is prepared by exposing magnesium to the radiations from radiothorium contained in a glass capsule, which is covered with silk paper (impermeable to ThX); as the emanation and ThA decay rapidly, the deposit soon consists only of ThB and ThC. The alloy is placed in a weighing bottle connected with an electroscope, and hydrochloric acid (or sulphuric acid) is dropped on the alloy while a current of nitrogen is passing; the strong indications of radio-activity decrease in a few minutes. Even when magnesium is superficially alloyed with ordinary bismuth and dissolved in HCl, a gaseous Bi compound (but not in similar experiments a Pb compound) is evolved which can be filtered through cotton wool; the effects observed were hence not due to ThC or to the volatility of thorium chloride. Polonium hydride is similarly prepared by electrolysing the faintly acid solution of polonium chlorides with a kathode of Mg. In HCl or H_2SO_4 a gas resembling bismuth hydride is evolved which does not decay in 24 hours, and is hence not due to polonium itself. The gas can be carried also by hydrogen or oxygen (instead of N). Only a few parts in 100,000 of the polonium are converted into hydride. The bismuth hydride is stable at ordinary temperature, decomposed at red heat, almost entirely condensed by liquid air, and can be re-gasified. The polonium hydride is partly condensed at − 84°; it ruins the electroscope used. *Bismuth Hydride.* II. **F. Paneth** and **E. Winternitz.** (*Ibid.*, pp. 1728–1743, 1918.)—In the preparation from non-radioactive materials the authors fuse the metals Mg, and Bi together in an iron crucible in a rapid stream of hydrogen; the alloy is dissolved in acid (also nitric acid), and yields sufficient hydride for the mirror test (Marsh apparatus) and the Donau luminescence test. In the former test a brown ring and, beyond it, a fainter ring is obtained; if a pierced clay disc is placed over the tube, and the gas flame plays against the clay, the mirror does not burn into the glass, and can chemically be tested. The yield of hydride with ordinary bismuth seems to be only 1/20 of that obtained with ThC, which is itself very small. In the Donau test the gas is ignited and a piece of pure calcium carbonate is held in the flame; bismuth is deposited on the lime, which, when subsequently placed with its edge in the flame, produces a luminescence of cornflower-blue tint. The bismuth hydride is absorbed by water, dilute acid, calcium chloride, soda, lime, to some degree best by solution of silver nitrate. The high density of these new hydrides is noteworthy. H. B.

1499. *Calculation of Chemical Constants of Polyatomic Gases.* **A[mélie] Langen.** (Zeits. Elektrochem. 25. pp. 25–45, Feb. 1, 1919.)—Recent advance in this problem is discussed with special regard to Nernst's heat theorem, Planck's quantum theory, and the determinations of Sackur and Tetrode. To arrive at the chemical constant of oxygen three equilibria are studied: the formation of ice from its elements at 273·1°; the formation of HgO from its elements; and the evaporation of solid oxygen. Similarly nitrogen and carbon dioxide are investigated. The chemical constants found are: Nitric oxide, + 0·92; oxygen, 1·021 to 0·530 (different calculations); carbon monoxide, − 0·04; nitrogen,

— 0·05; carbon dioxide, — 0·406; water, — 1·930; ammonia, — 2·454. From the results the $\beta\nu$ values of Einstein's specific-heat formula are deduced: Hydrogen, 430; ammonia, 67·5; water, 30; carbon dioxide, 7·25; oxygen, 0·736; nitric oxide, 0·543. These figures are, at any rate as to the order of magnitude, in accord with the moments of inertia derived from thermodynamical data. H. B.

1500. *Structural Distortion in Slimy-liquid Crystals.* **O. Lehmann.** (Ann. d. Physik, 61. 6. pp. 501–532, March 16, 1920.)—This is a further contribution on this question. Reference should be made to the original pages for the illustrations, without which the text is inadequate to describe the structures observed. L. H. W.

1501. *The Colour Laboratory of the U.S. Bureau of Chemistry.* **H. D. Gibbs.** (Chem. and Met. Eng. 22. pp. 405–407, March 3, 1920.)—The laboratory was organised in 1916 for the study of colours. A building in Arlington, Va., has been transformed into laboratories with manufacturing facilities; manufacture is only to be taken up if manufacturers are unable or unwilling to supply an article. The paper is a summary of the varied problems investigated: photographic sensitising dyes, vapour-phase chlorination and sulphonation of toluene, benzene, etc.; preparation of acetic acid by the fermentation (with the aid of a new organism) of xylose (from maize-corn cobs, the xylose need not be isolated) into acetic acid and lactic acid; preparation of isopropyl acetone from the propylene contained in the waste gases of the Burton process for cracking petroleum; and the production of coloured clouds for signalling on aircraft by discharging a dye solution, both dye and solvent being volatile, into the engine exhaust; the red clouds produced by Sudan II are visible at heights of 5000 ft. and more. On all these processes papers have been published, or are in preparation. H. B.

1502. *The Macroscopic Study of the Progress of Cooling of Steel Ingots.* **Descolas** and **Prétet.** (Comptes Rendus, 170. pp. 1048–1051, May 3, 1920.)—Describes a method of examination of steel ingots by attacking prepared sections with 20 % sulphuric acid in order to show up the progress of cooling to the interior of the metal. After washing with water brilliant specks are shown up at right angles to the cooling surface, their clearness depending on the maximum temperature reached and on the slowness of cooling. The specks are more easily seen in extra-mild steel than in hard steels, as they correspond to the presence of ferrite. An example is given showing the effect of the acid attack on an ingot of steel and also on an ingot of soft steel cast around a bar of extra-soft steel. C. O. B.

1503. *Structure of some Chromium Steels.* **J. H. G. Monypenny.** (Iron and Steel Inst., J. 101. pp. 493–518; Disc. and Corres., 519–525, 1920.)—The experimental results obtained on a series of steels containing from 1·5 to 15 % Cr are given, and it is shown that the effect of increasing amounts of Cr on the properties of steel is progressive; there do not appear to be boundaries which mark out ranges of composition where the properties change suddenly. Part of the carbide forming pearlite in the annealed or tempered condition does not dissolve at Ac_1, but progressively during a considerable range of temperature above this point.

This behaviour suggests the presence of two distinct carbides, although no microscopic evidence has been obtained of the presence of different carbides in the annealed samples. It is probable that it is the solution of this carbide which gives rise to the very great increase in the hardening properties of chromium steels in the range in which it dissolves; as, however, the increase in hardening property continues after the carbide has all dissolved, it is probable that dissociation takes place in the dissolved carbide, as suggested by Edwards. The rate of diffusion of carbides in Cr steels is much slower than in ordinary carbon steels, and a much longer time is required to produce equilibrium at any given temperature than with steels free from Cr. Chromium lowers the carbon content of the eutectoid point considerably. It also increases the solubility of cementite in austenite. The properties of austenitic Cr steels are of great theoretical interest, as they afford proof that martensite is the first stage in the decomposition of austenite. C. O. B.

1504. *Relationship between Dendritic Structure and Ferrite Mesh.* **F. Giolitti.** (Chem. and Met. Eng. 22. pp. 921–929, May 19, 1920.) —Shows that fir-tree crystals do not directly influence the location of ferrite shells either in ingot structure or after drastic heat treatments.

A method of duplex etching used to show up the primary dendrites and the free ferrite is described, which consists of deep etching with sulphuric acid to develop the dendrites, then the surface is partially repolished and etched with nitric acid.

From a large number of samples of ingot steel, containing 2 % Ni, examined by this method, it seems to be proved that there exists no constant relation between the reciprocal positions of dendritic elements and ferrite meshwork, although it is generally held that the secondary crystallisation (*i.e.*, of ferrite or cementite from austenite) is intimately affected by the system of dendrites, and the position of the ferrite boundaries determined by the difference in carbon concentration axis to periphery, of the primary austenite. Experiments on annealing showed that single heatings followed by slow cooling have little effect on the dendritic structure, but when heated above the transformation-point ferrite goes into solution, and on cooling is precipitated into a new meshwork, whose aggregation depends on the velocity of cooling. In order entirely to eliminate the dendritic structure, it was found to be necessary to carry out a triple quench after prolonged heating at very high temperatures. From this it follows that normalising heat-treatments based on diffusing the excess constituent and then preventing its re-segregation by rapid cooling past the critical range have far less effect on the dendritic system than on the ferrite network. The physical properties of normalised castings depend primarily on an improvement of the pearlite kernels by gradual diffusion of segregates. Granules, or coarse crystals in steel fractures, are shown to be connected very closely with the state of the ferrite meshwork rather than with the presence of fir-tree crystals. Tension tests show that fracture follows the ferrite meshwork or "ingot ferrite," but after annealing or normalising, the isolated ferrite crystallites do not exercise a major influence on the fracture. C. O. B.

1505. *Effect of Initial Temperatures upon the Physical Properties of Steel.* **J. H. Andrew, J. E. Rippon, C. P. Miller, and A. Wragg.**

(Iron and Steel Inst., J. 101. pp. 527–608, 1920. Engineering, 109. pp. 681–684, May 21, 1920. Abstract.)—The paper deals with the influence of the temperature from which the steel is cooled upon the resulting transformation points in certain nickel, chromium, and Ni-Cr steels. The physical properties examined include thermal changes, dilations, electrical resistivities, and magnetic measurements. A new form of dilatometer suitable for determinations at high temperatures is described. The volume change at the normal transformation points consists of two opposing changes, one due to the allotropic and the other to the carbide changes. The latter in steels of high carbon content is not complete until a much higher temperature has been reached than that at which all the ferrite or cementite has passed into solution. Evidence is put forward to support the view that dissociation of the carbide occurs at and above the transformation points. In nickel-chrome steels changes occur similar to those in carbon steels, but the time factor is of a lower order. Martensite is shown to be a product in which the allotropic change has been depressed by the associated carbide to a temperature at which the latter is able to exist in the α iron formed. During the normal transformation from austenite to pearlite, martensite is not formed as an intermediate product. By tempering austenite the carbide partly re-associates, when the γ iron passes into α iron and martensite results. The carbides separated electrolytically from nickel-chrome steels in which the transformation has not occurred at or about 600° C. are free from chromium. F. C. T.

1506. *On the Woody Fractures of Transverse Test-Pieces from certain Special Steels.* **J. J. Cohade.** (Iron and Steel Inst., J. 100. pp. 187–201; Disc. and Corres., 211–229, 1919. Engineering, 108. pp. 421–423, Sept. 26, 1919.)—In addition to the part played by non-metallic inclusions, blowholes, and amount of working, in giving bad results in transverse tests of forged parts, the chemical composition of the steel, and especially its carbon content, exerts its influence. Molybdenum steels are extremely liable to this defect. When the carbon is below 0·30 %, and, better still, below 0·25 %, good results are obtained even when special elements are present to secure high tensile strength. In nickel steels, so long as the percentage of that element is below 2·5, good results are obtainable, even with carbon content up to 0·5 %, but with more nickel lower carbon percentages are necessary. Transverse tests are improved if the forging of the ingot is wholly carried out at a high temperature; this improvement is, however, insufficient when the max. transverse strength is required. F. C. T.

1507. *Properties of Iron-Chromium-Carbon Steels.* I. *Thermal Analysis.* **C. A. Edwards, H. Sutton, and G. Oishi.** (Iron and Steel Inst., J. 101. pp. 403–446, 1920. Engineering, 109. pp. 692–694, May 21, 1920. Abstract.)—The temperature at which the carbides separate from solution during cooling is raised both by an increase of the carbon and of the chromium content of the steel, occurring at the highest temperature for any given chromium or carbon content when the ratio of Cr to C is 10 : 1. The authors conclude that in the annealed steels there exists a double carbide $Fe_3C . Cr_3C_2$. With a lower Cr/C ratio than this (4·3), Fe_3C will also be present, and none of the Cr present in solid solution, existing entirely in the form of isolated globules of carbide.

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With higher Cr contents some is present in solid solution, but the exact form of the higher carbide is uncertain. The authors regard it as being more likely that it is Cr_5C_2 than Cr_4C. In determining the influence of the critical temperature of cooling upon the critical cooling velocities, the steels are divided into two groups. With a Cr/C ratio not exceeding 10 the materials possess similar hardening characteristics to ordinary carbon steels, while with more Cr the steels become air hardening. The line dividing the groups is influenced by the impurities present, especially Mn and Si. F. C. T.

1508. *Chromium Steels.* II. *Effect of Heat Treatment on the Electrical Resistivity.* **C. A. Edwards** and **A. L. Norbury.** (Iron and Steel Inst., J. 101. pp. 447–482; Disc. and Corres., 483–492, 1920.)—In the annealed condition the effect of chromium is to raise the resistivity of iron by 3·75 microhms per 1 % Cr. This holds, however, only when the Cr/C ratio exceeds 4·3; with less Cr the effect on the resistance is negligible, due to the fact that virtually the whole of it is in combination with the carbon, which occurs in isolated patches, the iron being practically free. With Cr present in excess of 4·3 times the carbon, a certain proportion is present in solution in the iron. Quenching experiments show that on heating there exist two critical ranges, at the carbon change-point and at about 1000° C. respectively, and that not until the quenching temperature exceeds 1000° C. is the max. resistivity attained. On tempering also two critical ranges of temperatures were found at which the carbides fall out of solution. At about 200° C. what is probably Fe_3C comes out, while at 500–600° C. a second fall in the resistance takes place due to the precipitation of Cr_3C_2 or Cr_5C_2. For each 1 % of Cr actually in solid solution in iron an increase of 5·1 microhms per cm.-cube occurs. F. C. T.

1509. *Influence of Ionisation Tension on Chemical Reactions in Gaseous Mixtures, especially of Inert Gases.* **F. Skaupy.** (Zeits. f. Physik, 1. 1. pp. 49–50, 1920.)—When a current is first passed through a discharge tube filled with dilute neon the spectrum of the latter is almost always accompanied by that of carbon compounds, this being explained by the presence of impurities in the tube. If alkali metal kathodes and high currents, *e.g.*, 1 amp., are used, the carbon spectrum disappears in a fraction of a minute and the pure neon spectrum remains, but with tubes containing argon in place of neon, the carbon spectrum—due presumably to carbon monoxide—often persists for hours and disappears only slowly.

According to Franck and Hertz's results, the ionisation tensions of those carbon compounds as yet investigated lie between those of neon and argon. Thus, in presence of neon the carbon compound preferably attracts the electrons present and by their influence is either destroyed or converted into non-volatile compounds of high molecular weight, or possibly into solid carbon. On the other hand, in argon tubes the latter attract the electrons, from which the carbon compound is thus protected.

A similar phenomenon is observed in the purification of the rare gases from nitrogen by means of calcium carbide and calcium chloride. It is here found that the absorption of the last traces of nitrogen takes much longer with argon than with neon. This is probably due, not to a greater velocity of diffusion of the nitrogen into neon, but to differences in the ionisation tensions of neon and argon. The glowing reaction mass emits electrons which ionise the nitrogen, the charged molecules of the latter then reacting with the calcium carbide. Since the argon is more readily ionised than neon, it will withdraw more electrons of the reaction with the nitrogen than will neon, so that fewer nitrogen ions arise to react with the carbide.

It follows that even perfectly inactive gases are able to influence what are apparently purely chemical reactions. T. H. P.

1510. *Anodic Corrosion of Lead in Sodium Hydroxide Solutions.* **O. W. Brown, C. O. Henke,** and **L. T. Smith.** (J. Phys. Chem. 24. pp. 367–378, May, 1920.)—Anodes were cast from carefully refined electrolytic lead and employed in conjunction with lead kathodes in an electrolyte of sodium hydroxide solution. The current densities were varied in different experiments from 0·16 to 6·6 amps./dm.^{2} of anode, the temperature from 20° to 85° C. and the concentration of sodium hydroxide from 38 to 348 gm. per litre.

When the current is first applied, no gas is evolved at the anode, and the lead dissolves quantitatively. Afterwards, a grey spot appears suddenly, which rapidly spreads over the anode, and is followed by dark brown deposits of lead peroxide, which also spread over the surface when gas is liberated, and the corrosion of the anode is very materially reduced. The degree of corrosion is found to increase with the concentration of sodium hydroxide up to an amount of 152 gm. per litre. Above this concentration the curves which at different temperatures represent the change of corrosion with concentration of electrolyte fall rapidly. The corrosion increases rapidly with rise of temperature, and diminishes with increase of current density.

With an electrolyte of 110 to 170 gm. sodium hydroxide per litre, solution of the lead takes place quantitatively at a temperature of 75°, and nearly equal to the theoretical amount at 60° C. In some instances, with low current densities, the solution of the lead exceeds the amount theoretically required by the current. This deviation is shown to be due to corrosion taking place by chemical, apart from electrolytic, action

Measurements made by means of an auxiliary standard electrode, of the anode potential during electrolysis gave values varying from 3 volts to as low as 0·2 to 0·3, when the corrosion amounted to 100 %. The anodic and kathodic discharge potentials were measured during prolonged electrolysis when deposition of lead on the kathode was in progress. The back e.m.f. of polarisation was measured by means of a make-and-break commutator in the intervals immediately following the intermittent application of the electrolysis circuit.

The anodic polarisation varies from + 0·292 with a current density of 1·56 amps./dm.^{2} to − 1·317 with a current density of 4·22 amps./dm.^{2}, while the kathodic polarisation varies from + 0·47 to + 1·16 with the above current densities.

The curves expressing the relation between polarisation and current density show sudden bends, leading to max. values for the total polarisation, at 2·81 to 3·75 amps./dm.^{2}, which is the point at which the anode ceases to corrode quantitatively. J. N. P.